THE INSTITUTE OF PAPER CHEMISTRY

Appleton, Wisconsin

RELATIONSHIP BETWEEN COMBINED BOARD FLAT CRUSH AND CONCORA FLAT CRUSH

Project 1108-35

Report

to

Technical Division

FOURDRINIER KRAFT BOARD INSTITUTE, INC.

February 8, 1966

THE INSTITUTE OF PAPER CHEMISTRY
Appleton, Wisconsin

RELATIONSHIP BETWEEN COMBINED BOARD FLAT CRUSH AND CONCORA FLAT CRUSH

SUMMARY

Recently the Fourdrinier Kraft Board Institute, Inc., initiated a study to determine which Concora conditioning procedure is best related to combined board flat crush and, hence, which procedure would be most suitable for a referee test method. Three test procedures were studied, namely.

1. Testing immediately after fluting (5-8 sec.)
2. Conditioning for 30 ± 5 min. prior to testing
3. Conditioning for 24 ± 2 hr. prior to testing

Six corrugating plants representing different mills participated in the study. It was planned that each plant would select 30 samples of corrugated board over a 15-week period together with the corresponding corrugating medium samples. Four of the plants completed the sampling, however, two plants were not able to complete the study because of other commitments. Thus, plants E and F submitted only 19 and 15 samples, respectively.

The following results were obtained:

1. The three Concora procedures correlated almost equally well with combined board flat crush. Flat crush predictions using the three procedures were also about equally good

2. The above indicates that the deleterious effects which are claimed to occur during conditioning either do not occur, or do not affect the relationship with combined board flat crush By the same token, the unstable moisture condition

associated with "immediate" testing did not adversely affect the relationships with combined board flat crush to any great degree.

3. The correlation coefficients for the individual plants and the composite correlation coefficients were appreciably lower than claimed by Long and Hallenfort, as shown below

	Concora Conditioning Time		
	5-8 sec.	30 min.	
Mill Results:			
Maximum	0.779 (Mill E)	0.825 (Mill C)	0.774 (Mill C)
Minimum	.600 (Mill B)	.468 (Mill F)	.508 (Mill D)
Composite	.769	.767	.765
I.P.C. Results:			
Maximum	0.838 (Mill F)	0.912 (Mill F)	0.873 (Mill F)
Minimum	.445 (Mill D)	.566 (Mill B)	613 (Mill A)
Composite	.789	.787	.793

It is evident that the manner of conditioning does not materially affect the magnitude of the correlation coefficient.

4. The 5-8 sec. tolerance for the time interval between the specimen emerging from the fluter and the beginning of loading seems unrealistically short. In this connection one participant found it necessary to use a tolerance of 10-13 sec.

5. When the same medium rolls were fabricated by each of the participants, marked differences in combined board flat crush occurred. As would be expected different flute contours, roll conditions, operating efficiency, etc., can cause significant differences in combined board flat crush.

INTRODUCTION

In performing the Concora medium test, the conditioning treatment given the specimen after fluting has been a controversial question for years The argument has hinged on whether the specimen should be

a tested immediately after fluting, or

b. conditioned at 50% R H. for a period of time prior to testing

Maltenfort, among others, has advocated testing immediately after fluting. A survey summarizing his viewpoint may be found in reference (1) Others in the industry, including the Institute, have felt that a conditioning time after fluting should be favored for "referee" test purposes

In addition to the references cited by Maltenfort in his survey (1), the following reports to the Fourdrinier Kraft Board Institute, Inc present information bearing on one or more aspects of the problem.

1 An instrumentation study of the Concora medium fluter
Project 1108-11, Report One. May 1, 1959
This report discusses a variety of instrumental variables including the effect of moisture and conditioning on flute height and test results.

2. Relationship between conditioned and unconditioned Concora results and their relationship with single-faced flat crush.
Project 1108-11. Report Three April 11, 1960.
In this report conditioned and "hot" Concora results were correlated with single-face flat crush using materials from

the medium baseline study. For 12 out of 17 participants the conditioned Concora results gave equal or better correlation coefficients than the "hot" Concora results. The overall correlation coefficients were nearly equal for the two procedures -- 0.81 to 0.78 for the conditioned and unconditioned Concora results, respectively.

From one standpoint it would be desirable to select the procedure which exhibits the best correlation with combined board flat crush. To supplement the work cited in Maltenfort's survey and the above reports, a new study was initiated by the Fourdrinier Kraft Board Institute, Inc. (see Minutes of Concora Subcommittee Meeting, January 19, 1965) to determine the relationship between flat crush in commercial corrugated boards and Concora flat crush tested as follows:

a. immediately

b. after conditioning 30 min.

c. after conditioning 24 hr.

In brief outline, it was planned that each of six corrugating plants would select two samples of 175 or 200-lb. test board per week for 15 weeks of 26-lb. "run of the mill" corrugating medium and the corresponding combined board. Both the Institute and the companies concerned were to evaluate the mediums for Concora flat crush as noted above and the combined board for flat crush.

This report summarizes the results obtained.

Participants.

The following companies participated in the study.

	Company	Plant Location
1.	Container Corporation of America	Anderson, Indiana
2.	Crown Zellerbach Corporation	Milwaukee, Wisconsin
3.	International Paper Company	Georgetown, South Carolina
4.	Owens-Illinois, Inc.	Bradford, Pennsylvania
5.	Union Bag-Camp Paper Corporation	Savannah, Georgia
6.	Weyerhaeuser Company	Olympia, Washington

Procedure.

The detailed procedures used in sampling and testing are outlined in Appendix A. The characteristics of the compression test equipment used by the plants and the T.P.C. are shown in Table I

It may be noted that two of the participants were not able to complete the collection of the full 30 samples due to the nature of their order distribution

As understood at the Institute the "immediate" Concora tests were to be performed so that the time period between when the specimen emerges from the flutes to the moment when load is brought to bear should be no more than 5-8 sec. To comply with this tolerance a micro-switch was installed on the H & D tester to limit the upper travel of the upper platen. This minimized delay between operating the tester and bringing load to bear on the specimen. It was also found necessary to precut the tape to avoid any delay in its application

One participant reported that their "immediate" Concora tests were

carried out in 10-15 sec. rather than 5-8 sec

In one or two instances, difficulties were encountered with the 24-in specimens due to the tape pulling loose during the conditioning period

TABLE I

COMPRESSION TESTER CHARACTERISTICS

Plant Code	Concora Tests: Compression Tester Type	Concora Tests: Compression Tester Capacity, lb.	Concora Tests: Test Rate, lb /sec	Combined Board Flat Crush: Compression Tester Type	Combined Board Flat Crush: Compression Tester Capacity, lb	Combined Board Flat Crush: Specimen Size, sq in	Combined Board Flat Crush: Test Rate, lb./sec.
A	H & D	--	29 4	H & D	--	5	29.4
B	H & D	500	18	H & D	1000	10	50
C	H & D	--	21	H & D	--	5	28
D	H & D	500	25	H & D	500	5	25
E	H & D	500	28.8	H & D	1000	10	29.6
F	H & D	--	25	H & D	--	5	50
IPC	H & D	500	15	H & D	500	5	15

DISCUSSION OF RESULTS

The Institute and mill data for the individual samples are tabulated in Appendix II. The regression coefficients -- intercept and slope -- for the Concora vs. combined board flat crush correlations are also tabulated in Appendix II.

The correlations between combined board flat crush and Concora are summarized in Table II for each participant. Scatter diagrams for each plant are shown in Fig. 1 - 12. In Table III, the three procedures have been ranked in terms of the following:

a. correlation coefficient, and

b. combined board flat crush prediction

Inspection of the results indicates there is no great difference between conditioning procedures with respect to their relationship to combined board flat crush. This is in agreement with the 1960 medium baseline study cited in the Introduction

The correlation coefficients exhibit the following range.

	5-8 sec.	30 min	24 hr.
Mill Results			
Maximum	0.779 (Mill E)	0.825 (Mill C)	0.774 (Mill C)
Minimum	.600 (Mill B)	.465 (Mill F)	.508 (Mill D)
Composite	769	.767	.765
I.P.C Results			
Maximum	0.838 (Mill F)	0.912 (Mill F)	0.873 (Mill F)
Minimum	445 (Mill D)	566 (Mill B)	.615 (Mill A)
Composite	.789	.787	.793

TABLE II

SUMMARY OF CORRELATION RESULTS

Mill	N	Average Combined Board Flat Crush p.s.i.	Average Concora Flat Crush, p.s.i.			Correlation Coefficient			Average Prediction Diff.[a], %		
			5-8 sec.	30 min.	24 hr.	5-8 sec.	30 min.	24 hr.	5-8 sec.	30 min.	24 hr.
					Mill Results						
A	30	39.1	49.3	40 8	41.6	0.673	0.693	0.720	3.65	3.55	3.51
B	29	34.9	44.9	35.0	35.6	0.600	0.689	0 620	5.39	4.64	5.07
C	30	32.7	43.8	34.4	35.2	0.760	0.825	0.774	5.94	5 17	5 85
D	30	32.1	40.0	32 5	33.4	0.616	0.534	0.508	4.51	4.41	4 64
E	19	31 2	42.5	35.7	36.3	0.779	0.600	0.600	3.28	4.62	4 65
F	15	34.2	41.6	36.7	36.5	0.653	0.468	0.598	5.71	6.92	6.40
Composite	153					0.769	0.767	0.763	5.81	6.00	6.06
					I.P.C. Results						
A	30	37.8	51.2	40.1	41.0	0.507	0.625	0.613	3.62	3.22	3.22
B	29	34.1	43.4	34.4	35.1	0.579	0.566	0.656	4.91	5.04	4.48
C	30	32.1	44.1	33.9	34.8	0.761	0.740	0.770	4.98	5 03	4.88
D	30	30.2	40.9	32.5	33.4	0.445e	0.637	0.636	4.77	4.35	4.24
E	19	30.4	42.8	34.1	34.8	0.632	0.667	0.633	4.98	5.02	4 86
F	15	31.5	44.7	36.9	37.6	0.838	0.912	0.873	4.51	3.52	3.87
Composite	153					0.789	0.787	0.793	5.61	5.68	5.59

[a] [illegible] difference in per cent between the observed and calculated [illegible] using the appropriate regression equation.

TABLE III

RANKING OF CONCORA CONDITIONING PROCEDURE BY CORRELATION COEFFICIENT AND PREDICTION DIFFERENCES

		Correlation Coefficient Ranking			Prediction Ranking		
Code	N	5-8 sec.	30 min.	24 hr.	5-8 sec.	30 min.	24 hr.
			Mill Results				
A	30	3	2	1	3	2	1
B	29	3	1	2	3	1	2
C	30	3	1	2	3	1	2
D	30	1	2	3	2	1	3
E	19	1	2.5	2.5	1	2	3
F	15	1	3	2	1	3	2
Composite	153	1	2	3	1	2	3
			I.P.C. Results				
A	30	3	1	2	3	1.5	1.5
B	29	2	3	1	2	3	1
C	30	2	3	1	2	3	1
D	30	3	1.5	1.5	3	2	1
E	19	2.5	1	2.5	2	3	1
F	15	3	1	2	3	1	2
Composite	153	2	3	1	2	3	1
Total		30.5	27	26.5	31	28.5	24.5

These coefficients are considerably lower in magnitude than were reported by Long and Maltenfort (2), but roughly the same as obtained in past Institute work. In Maltenfort's survey (1), he attributed the lower coefficients obtained in past Institute work to the Concora conditioning procedure. It is evident from the above that this is not the reason.

There are a number of reasons which could account for the differences in correlation magnitude. For example, it is often observed that, the greater the range of dependent and independent variables, the higher the correlation coefficient. In the original work by Long and Maltenfort (2), the A-flute correlation was based on data wherein the combined board flat crush ranged from about 15 to 35 p.s.i. [see Fig. 1, reference (2)] -- a difference of about 20 p.s.i. The individual plants in this study submitted combined boards which differed in flat crush by from 8 to about 14 p.s.i. This lower range could easily account for the individual plant correlations being lower than the 0.93 reported by Long and Maltenfort.

As an illustration of the effect of the range of the variables on the correlation coefficient, the correlations were also obtained after omitting the results for two of the more extreme data points for each plant. The results are shown in Table IV. As may be noted, deletion of only two sample points was sufficient to produce a marked reduction in correlation in a number of cases.

While the correlation coefficient can be a misleading criterion for the strength of a relationship, the average prediction difference is often less confusing. These results in Table II and rankings in Table III also indicate there is little difference between conditioning procedures. On the average, predictions of combined board flat crush will be within about 5 or 6% of the observed

TABLE IV

COMPARISON OF CORRELATION COEFFICIENTS BEFORE AND AFTER OMISSION OF TWO EXTREME SAMPLES

Mill	Sample Numbers Deleted	Number of Samples Before Deletion	Number of Samples After Deletion	Correlation Coefficient 5-8 sec. Before Deletion	5-8 sec. After Deletion	30 min. Before Deletion	30 min. After Deletion	24 hr. Before Deletion	24 hr. After Deletion
				Mill Results					
A	1 & 10	30	28	0.673[a]	0.383[b]	0.693[a]	0.362[b]	0.720[a]	0.449[a]
B	22 & 27	29	27	0.600[a]	0.127	0.689[a]	0.259	0.620[a]	0.172
C	4 & 22	30	28	0.760[a]	0.557[a]	0.825[a]	0.687[a]	0.774[a]	0.540[a]
D	11 & 18	30	28	0.616[a]	0.453[a]	0.534[a]	0.465[a]	0.508[a]	0.458[a]
E	10 & 12	19	17	0.779[a]	0.878[a]	0.600[a]	0.562[b]	0.600[a]	0.602[b]
F	10 & 11	15	13	0.653[a]	0.529[b]	0.468	0.442	0.598[b]	0.617[a]
				I.P.C. Results					
A	1 & 10	30	28	0.507[a]	0.086	0.625[a]	0.326[b]	0.613[a]	0.202
B	22 & 27	29	27	0.579[a]	0.071	0.566[a]	0.085	0.656[a]	0.170
C	4 & 22	30	28	0.761[a]	0.579[a]	0.740[a]	0.527[a]	0.770[a]	0.600[a]
D	11 & 18	30	28	0.445[b]	0.363[b]	0.637[a]	0.613[a]	0.636[a]	0.596[a]
E	10 & 12	19	17	0.632[a]	0.643[a]	0.667[a]	0.616[a]	0.633[a]	0.630[a]
F	10 & 11	15	13	0.838[a]	0.851[a]	0.912[a]	0.917[a]	0.873[a]	0.858[a]

[1] Significant at the 1% level

[2] Significant at the 5% level

Note: Underlined values not significant at the 5% level

value using any of the procedures

The regression lines obtained for each plant are shown in Fig. 13 As may be noted, the individual regression lines for the six plants were appreciably different. The regression line slope for Plant C, in particular, was much greater than for the remaining mills

The composite regression lines for the 5-8 sec. Concora results are in reasonably good agreement with the relationship given by Long and Maltenfort (2). This is shown in Fig. 14 The equations are as follows:

Composite (Plant)	F = 53.5 + 3.94 CMT
Composite (I.P C.)	F = 43 7 + 3.85 CMT
Long and Maltenfort (2)	F = 44.86 + 3.97 CMT

In the range of interest, it appears that the three equations would give quite similar predictions

In addition to the periodic sampling of corrugating medium rolls and the combined board made therefrom, three commercial rolls of corrugating medium were selected for fabrication on the same six corrugators used in the periodic sampling phase of this study The purpose of this phase is to determine the degree to which the six corrugators can achieve a common Flat Crush level per roll. The three rolls of medium were made by the Georgetown mill of International Paper Company. The procedure involved starting each roll at a different corrugating plant. Each corrugator fabricated 2000 lineal feet or less of combined board from each roll of medium and then shipped it to another participant The sequence of corrugating is tabulated below for each roll

Corrugating Sequence	Roll A	Roll B	Roll C
1	C	A	E
2	D	F	B
3	B	C	F
4	A	B	A
5	E	E	C
6	F	*	*

* - Corrugator D did not indicate date of fabrication

Samples of corrugating medium and combined board were selected from each fabrication run and evaluated using the procedure outlined for the periodic sampling phase of the study. The fabrication data obtained are given in Table V. The flat crush and Concora results are tabulated in Table VI. In general, the maximum variation in flat crush is equivalent to approximately 15% based on the respective roll averages. The maximum variation in flat crush appears to be slightly greater for flat crush than for the Concora results. The results do not indicate any clear superiority of one corrugator over the other, although the results obtained on mill C (considering both mill and I.P.C. results) were highest in three of the six instances.

Literature Cited

1. Maltenfort, G. G. TAPPI 47, no. 12 176A-185A (December 1964)

2. Long, P. D. and Maltenfort, G. G. Fibre Containers 37, no. 12 86, 91, 92 (December 1952)

TABLE V

FABRICATION DATA ON TRAVELING ROLLS

Traveling Roll No.	Corrugator	Date Corrugated	Adhesive	Trim Width, in.	Corrugator Speed, f.p.m.	Flat Crush, p.s.i. Mill	Flat Crush, p.s.i. I.P.C.
A	A	7-14-65	Starch	75	180	43.7	42.1
	B	6-15-65	"	75	200	41.7	39.7
	C	5-19-65	"	60	300	40.7	40.3
	D	6- 2-65	"	--	200	38.9	36.3
	E	10-13-65	"	75	400	41.6	39.9
	F	11-11-65	"	75	300	44.7	37.5
B	A	5- 7-65	Starch	75	150	40.5	38.0
	B	9-10-65	"	75	245	37.8	37.7
	C	8- 5-65	"	75	350	43.8	38.5
	D	--	--	--	--	39.9	38.2
	E	10-13-65	"	75	410	39.2	37.3
	F	7-11-65	"	75	350	42.8	36.5
C	A	9-22-65	Starch	75	150	42.0	39.3
	B	8-20-65	"	75	245	39.2	37.7
	C	10-15-65	"	75	250	40.0	42.1
	D	--	--	76	250	40.5	36.3
	E	6-18-65	"	75	250	36.1	35.0
	F	9- 8-65	"	75	280	39.8	35.1

TABLE VI

RESULTS OBTAINED ON TRAVELING ROLLS

Roll No	Corrugator	Concora Results						Flat Crush, p s i.	
		Mill			I P C.				
		5-8 sec	30 min	24 hr	5-8 sec.	30 min.	24 hr.	Mill	I P.C
A	A	52.3	42.8	46.3	54.1	43.3	42.5	43.7	42.1
	B	57.2	44.9	44.5	56.4	43.7	45.9	41.7	39.7
	C	51.0	41.9	--	52.4	41.4	42.2	40.7	40.3
	D	53.0	42.5	43.0	55.5	44.4	44.2	38.9	36.3
	E	55.0	48.1	48.1	56.6	46.8	46.7	41.6	39.9
	F	49.9	45.4	40.3	54.5	40.7	43.0	44.7	37.5
Average		53.1	44.3	44.4	54.9	43.4	44.1	41.9	39.0
Range		7.3	6.2	7.8	4.2	6.1	4.5	5.8	5.8
B	A	51.8	43.3	44.9	51.5	40.5	42.4	40.5	38.3
	B	54.4	41.0	40.2	49.4	39.3	39.1	37.8	37.7
	C	50.-	41.0	40.8	51.5	40.3	41.1	43.8	38.5
	D	52.9	39.8	40.9	52.1	40.2	41.6	39.9	38.2
	E	49.3	42.5	43.6	52.3	42.0	42.7	39.2	37.3
	F	50.2	44.6	43.1	52.0	40.1	42.4	42.8	35.5
Average		51.5	42.0	42.3	51.5	40.4	41.6	40.7	37.0
Range		4.2	4.8	4.7	2.9	5.6 / 2.7	3.6	6.0	2.3
C	A	49.5	40.3	39.8	50.7	41.2	41.3	42.0	39.3
	B	52.3	41.2	41.5	51.8	39.3	40.1	39.2	37.1
	C	49.1	40.5	40.8	51.4	40.7	40.6	40.0	42.1
	D	51.3	38.6	38.2	48.7	39.9	40.8	40.5	36.3
	E	49.7	44.3	43.8	52.8	41.0	41.4	36.1	35.0
	F	49.5	39.2	38.9	48.0	39.4	39.2	39.8	35.1
Average		50.-	40.7	40.5	50.6	40.3	40.6	39.6	37.5
Range		3.2	5.7	5.6	4.8	1.9	2.2	5.9	7.0

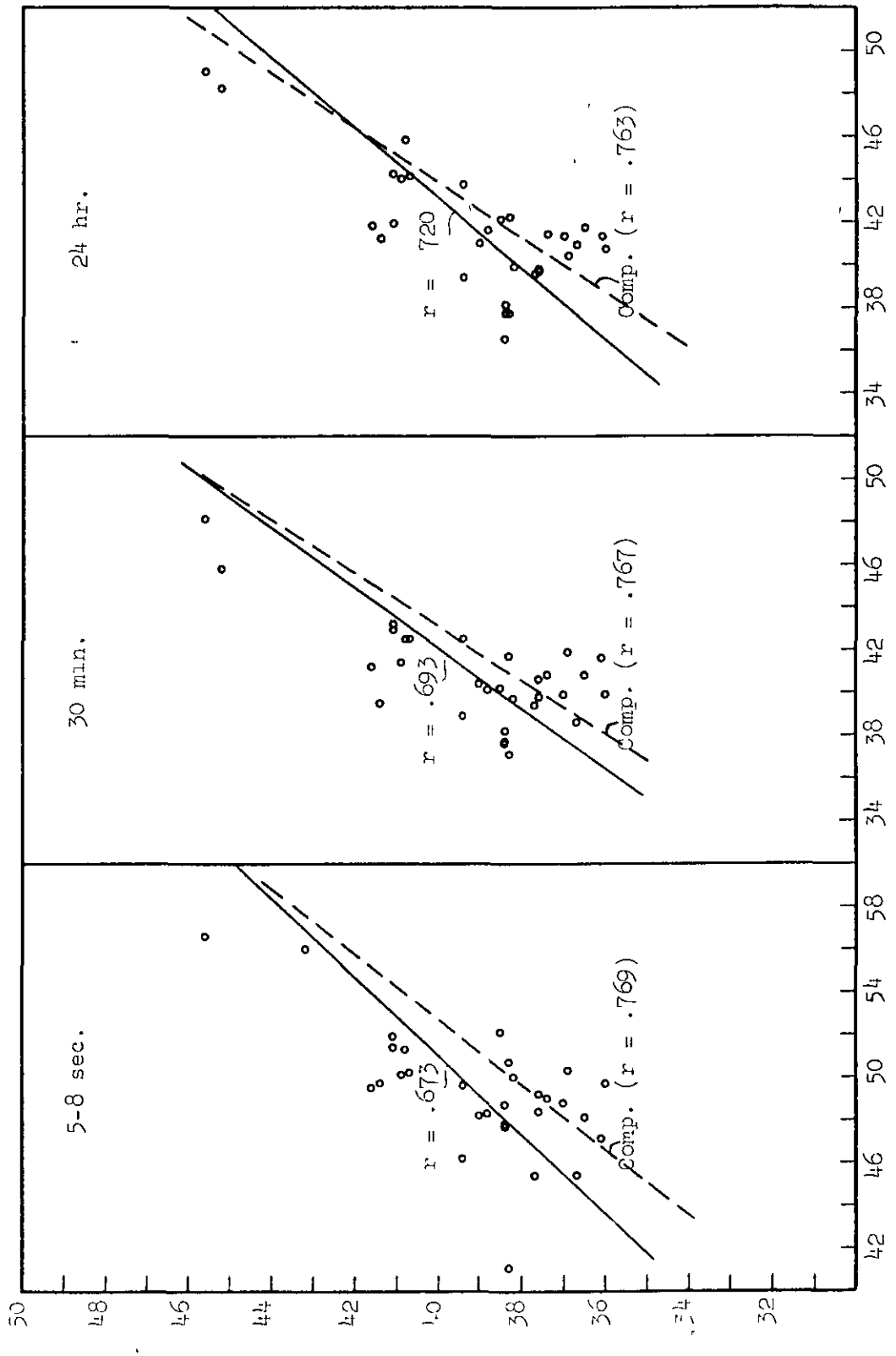


Figure 1 Relationship between Concora Medium Test and Combined Board Flat Crush for Mill A (Mill Results)

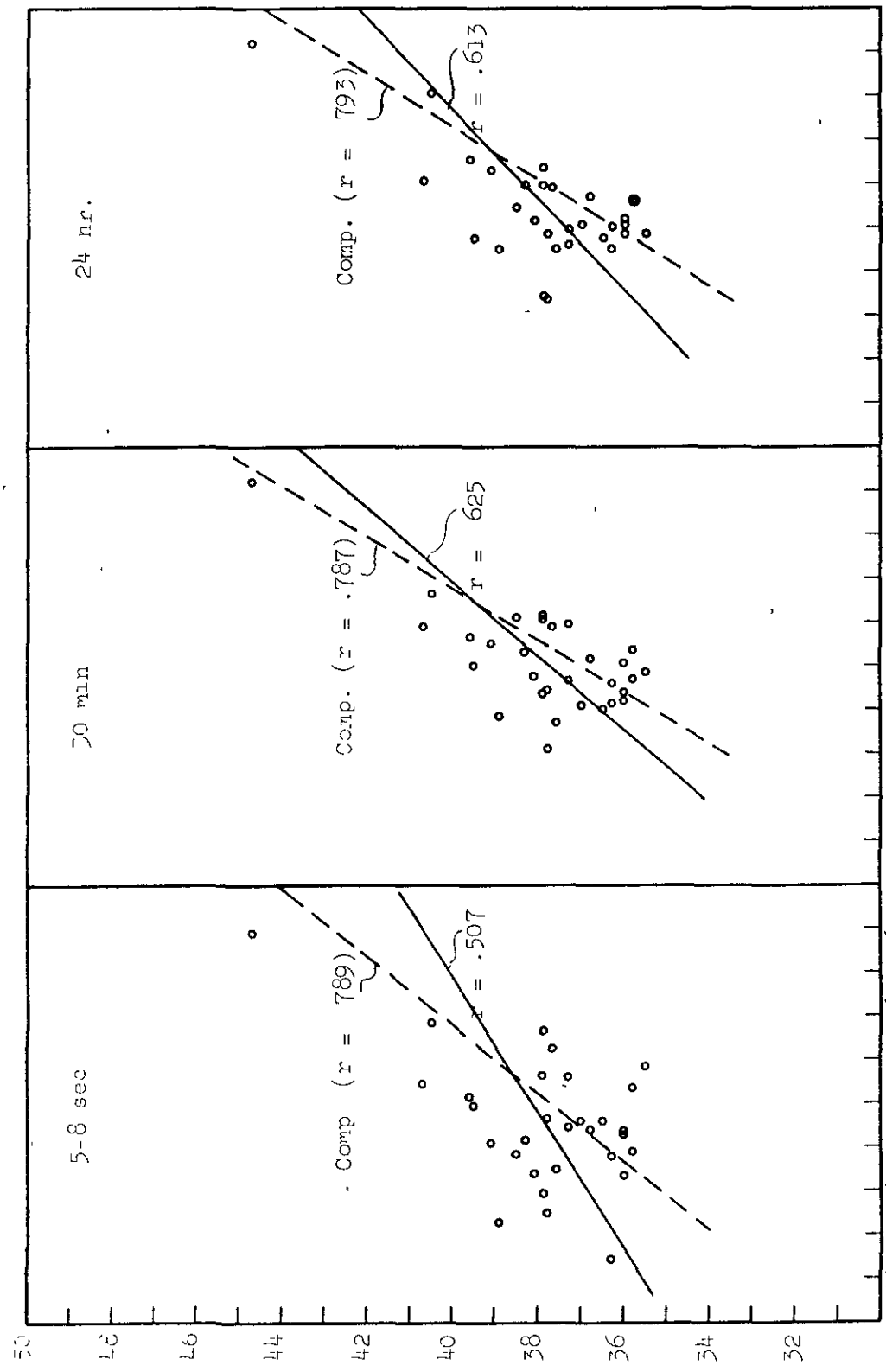


Figure 2 Relationship between Concora Medium Test and Combined Board Flat Crush for Mill A
(I.I C. Results)

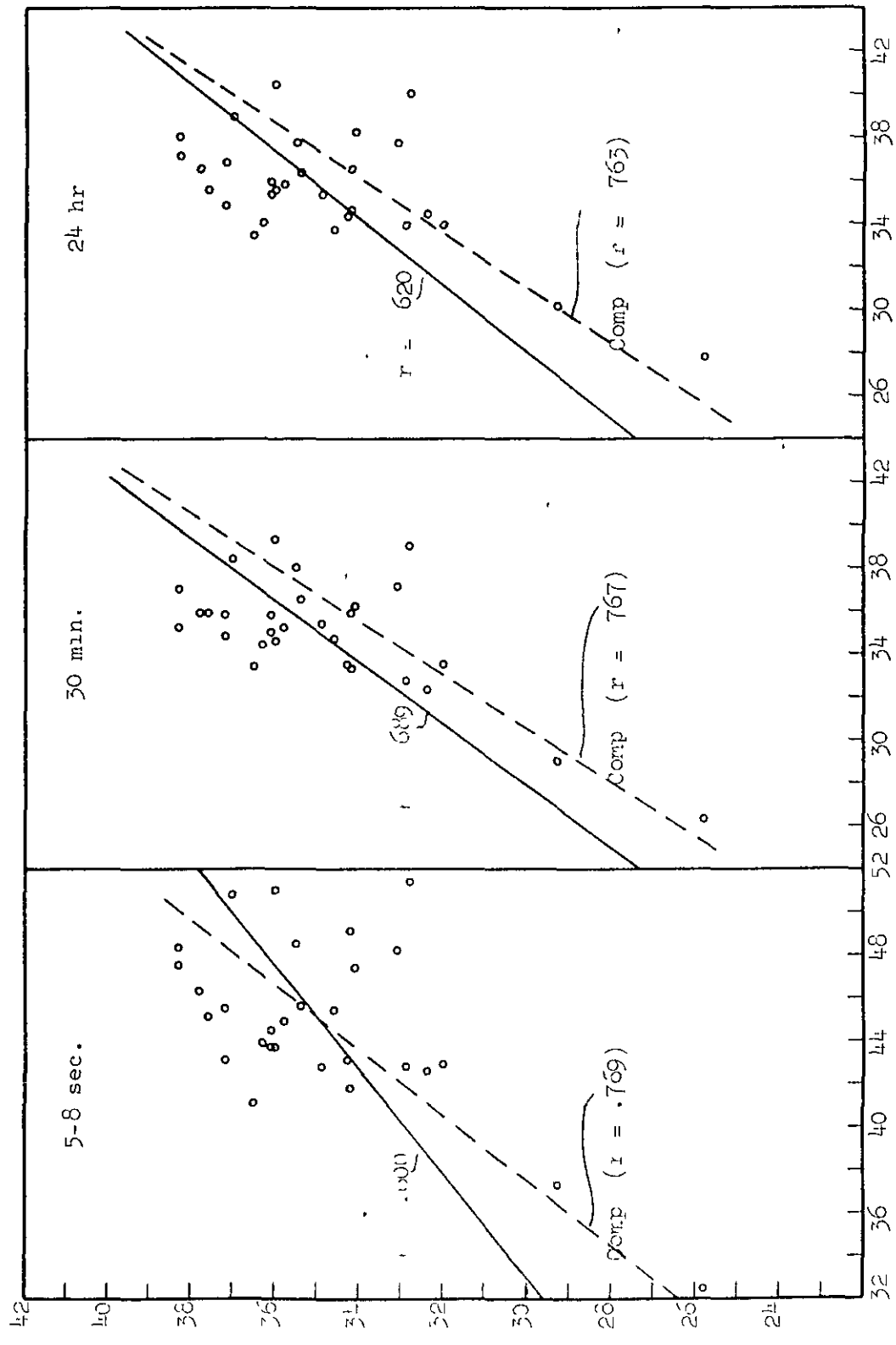


Figure 3. Relationship between Concora Medium Test and Combined Board Flat Crush for Mill 3 (Mill Results)

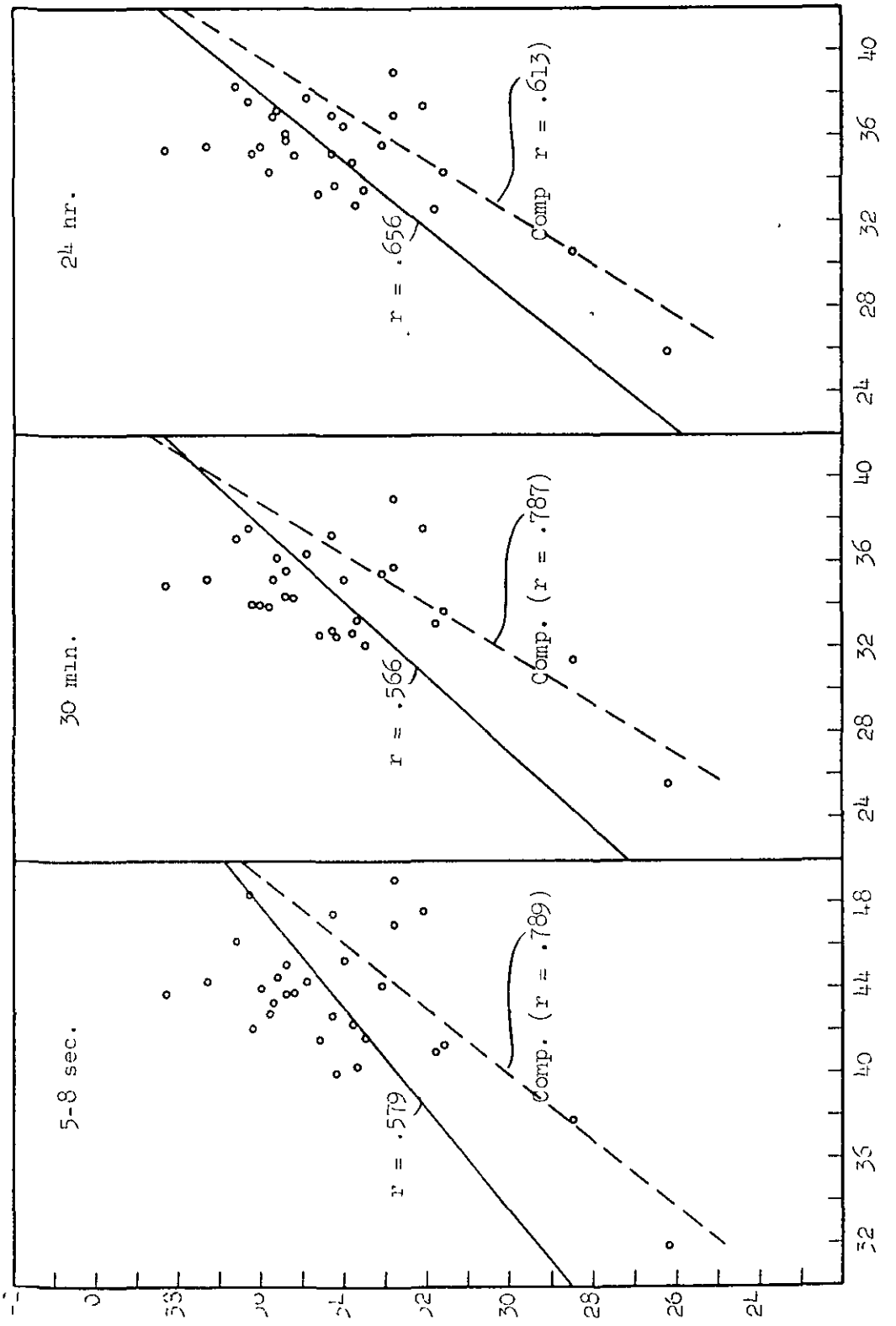


Figure 4. Relationship between Concora Medium Test and Combined Board Flat Crush for Hall B (I.P.C. results)

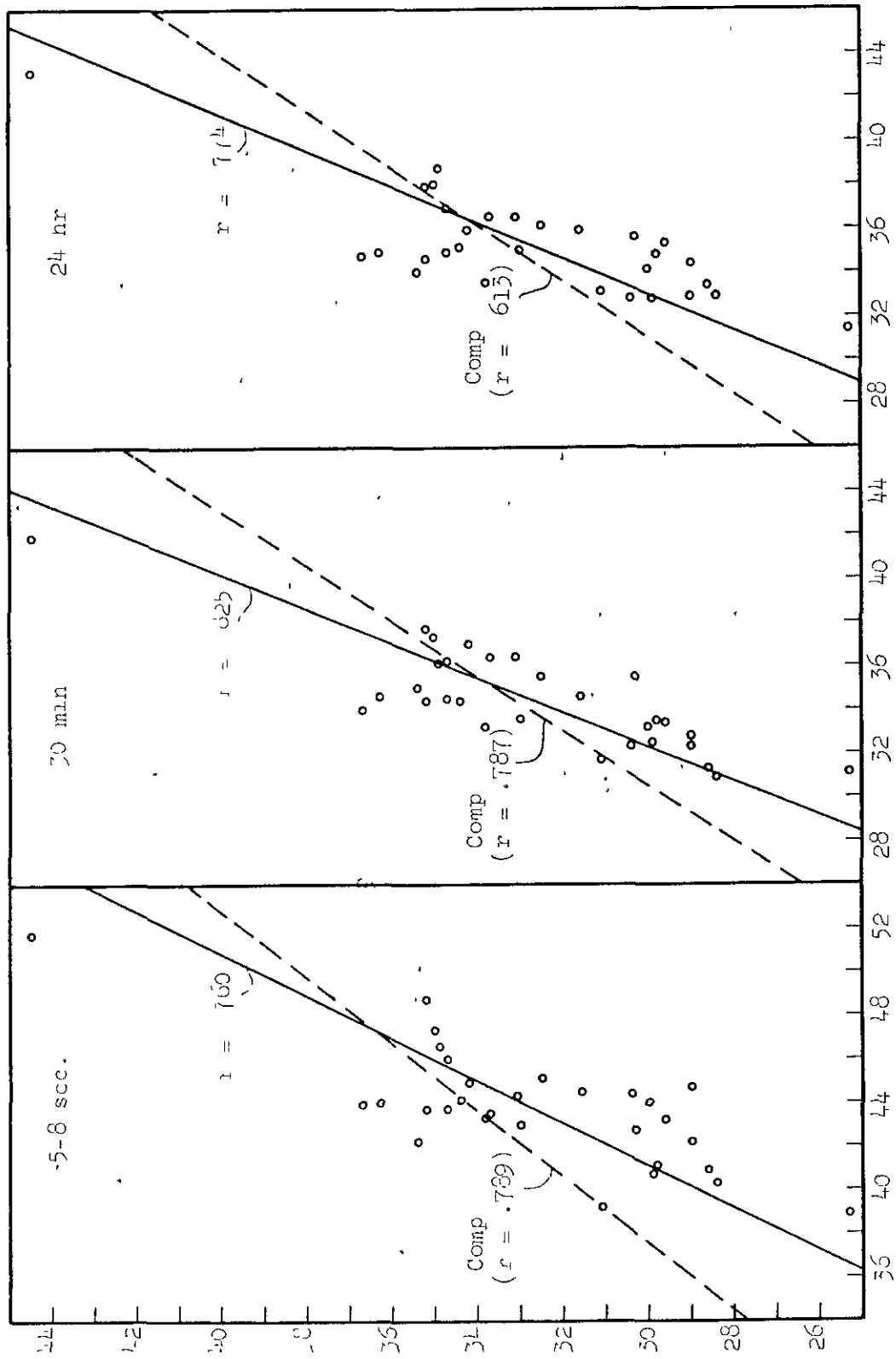


Figure 5. Relationship between Concora Medium Test and Combined Board Flat Crush for Mill C
(Mill Results)

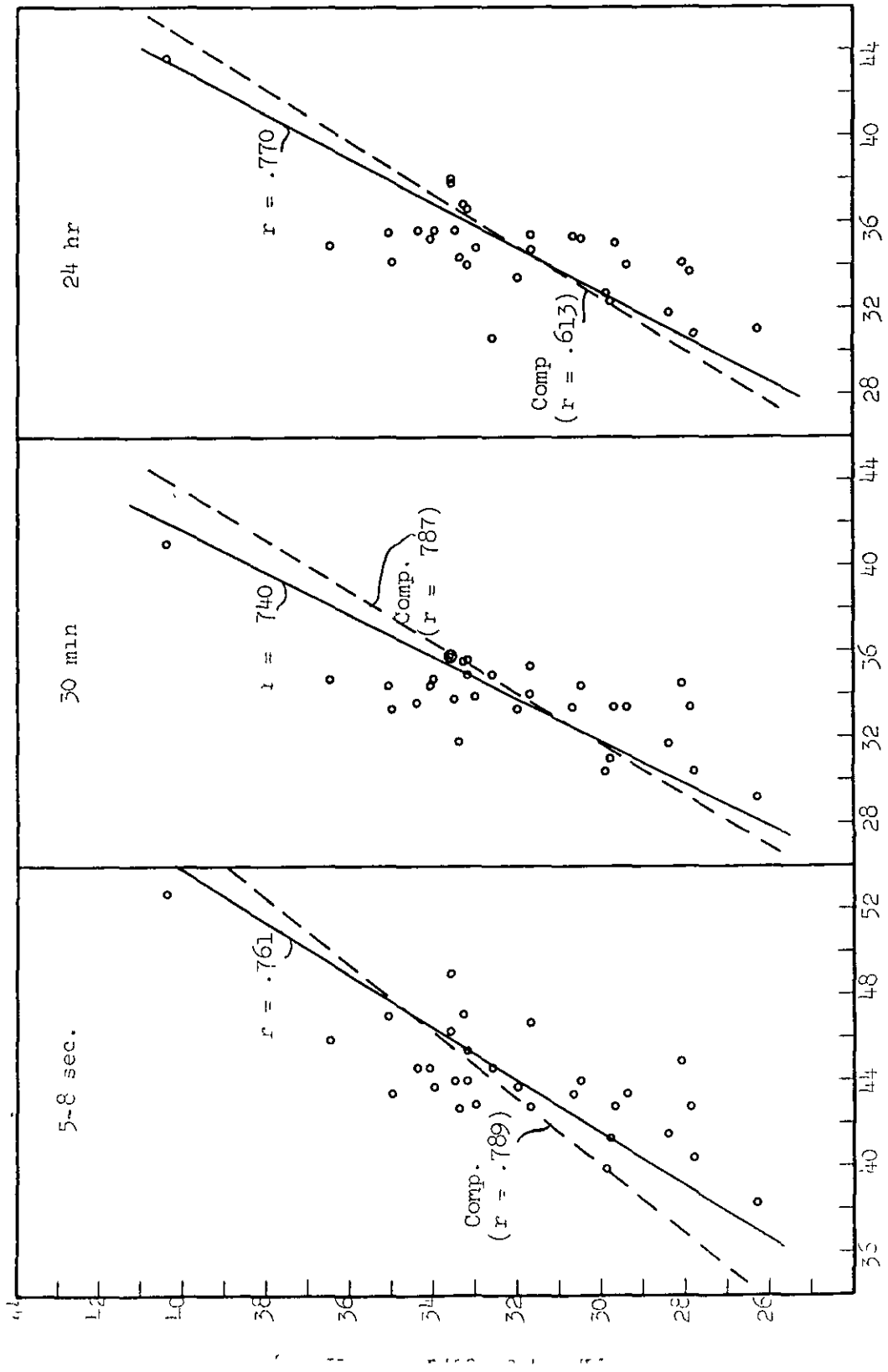


Figure 6 Relationship between Concora Medium Test and Combined Board Flat Crush for Mill C
(I.P C. Results)

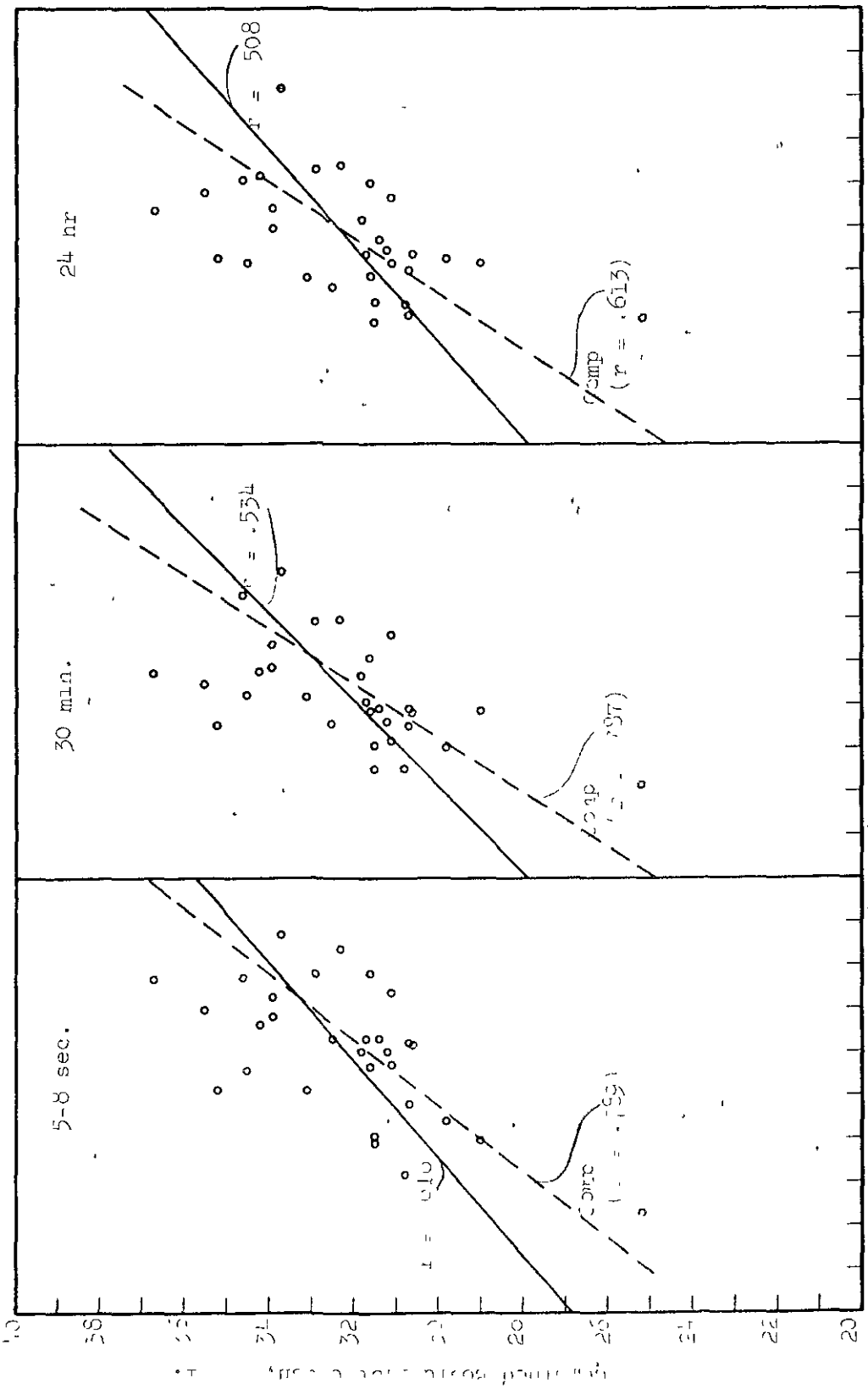


Figure 7 Relationship between Concora Medium Test and Combined Board Flat Crush for Mill D
(Mill Results)

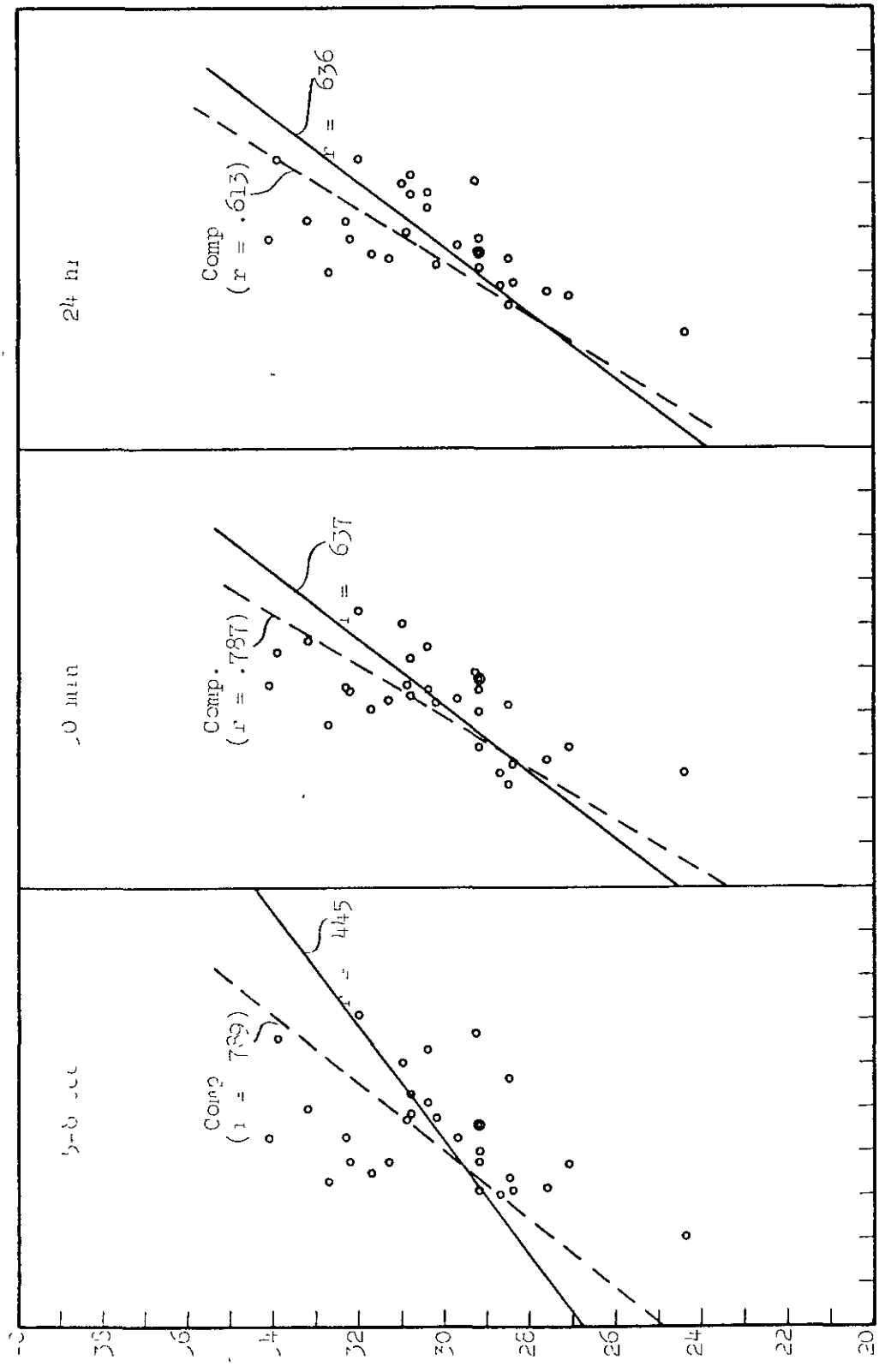


Figure 3 Relationship between Concora Medium Test and Combined Board Flat Crush for Mill D
(I.P.C Results)

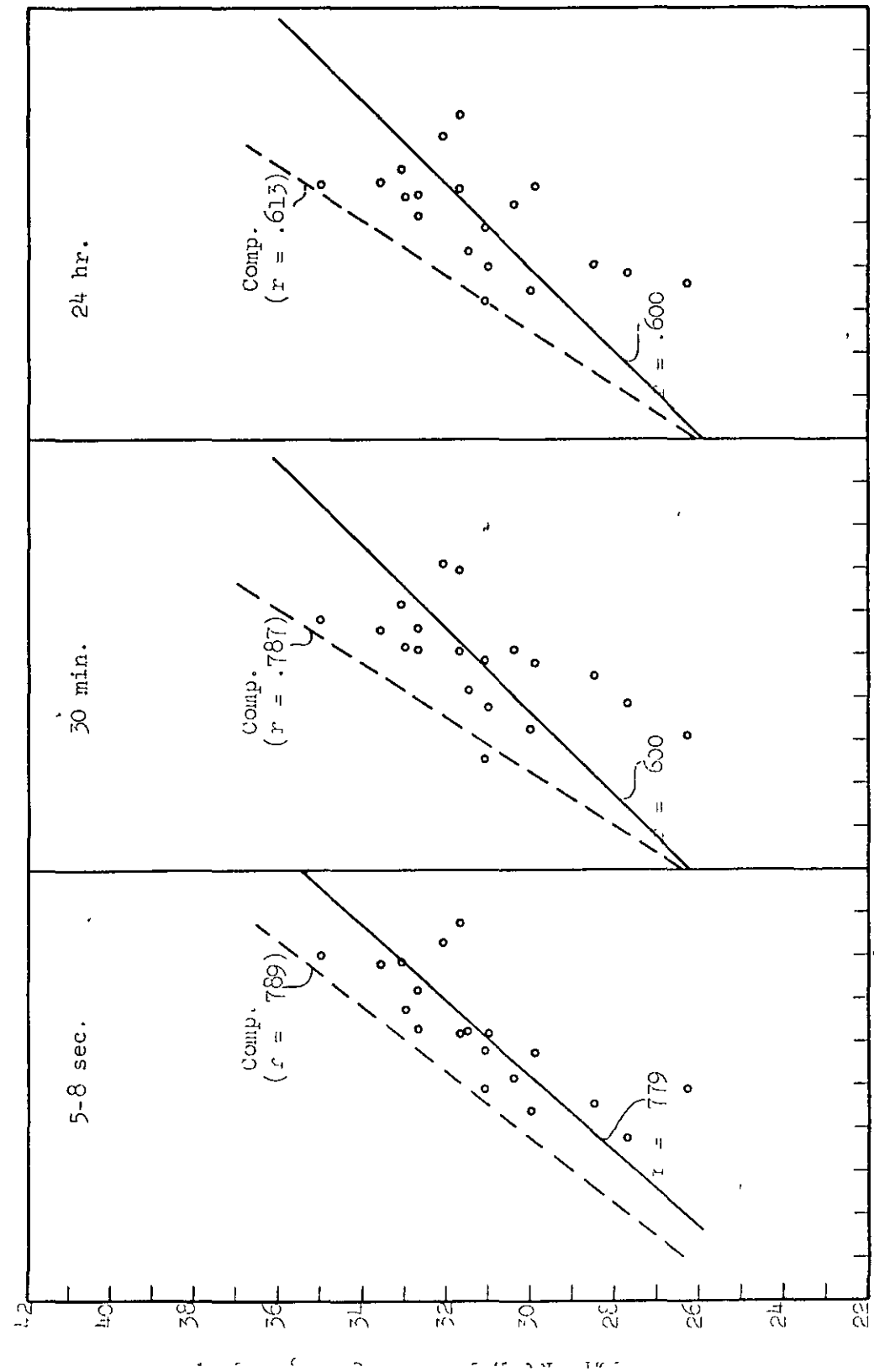


Figure 9. Relationship between Concora Medium Test and Combined Board Flat Crush for Mill E (Mill Results)

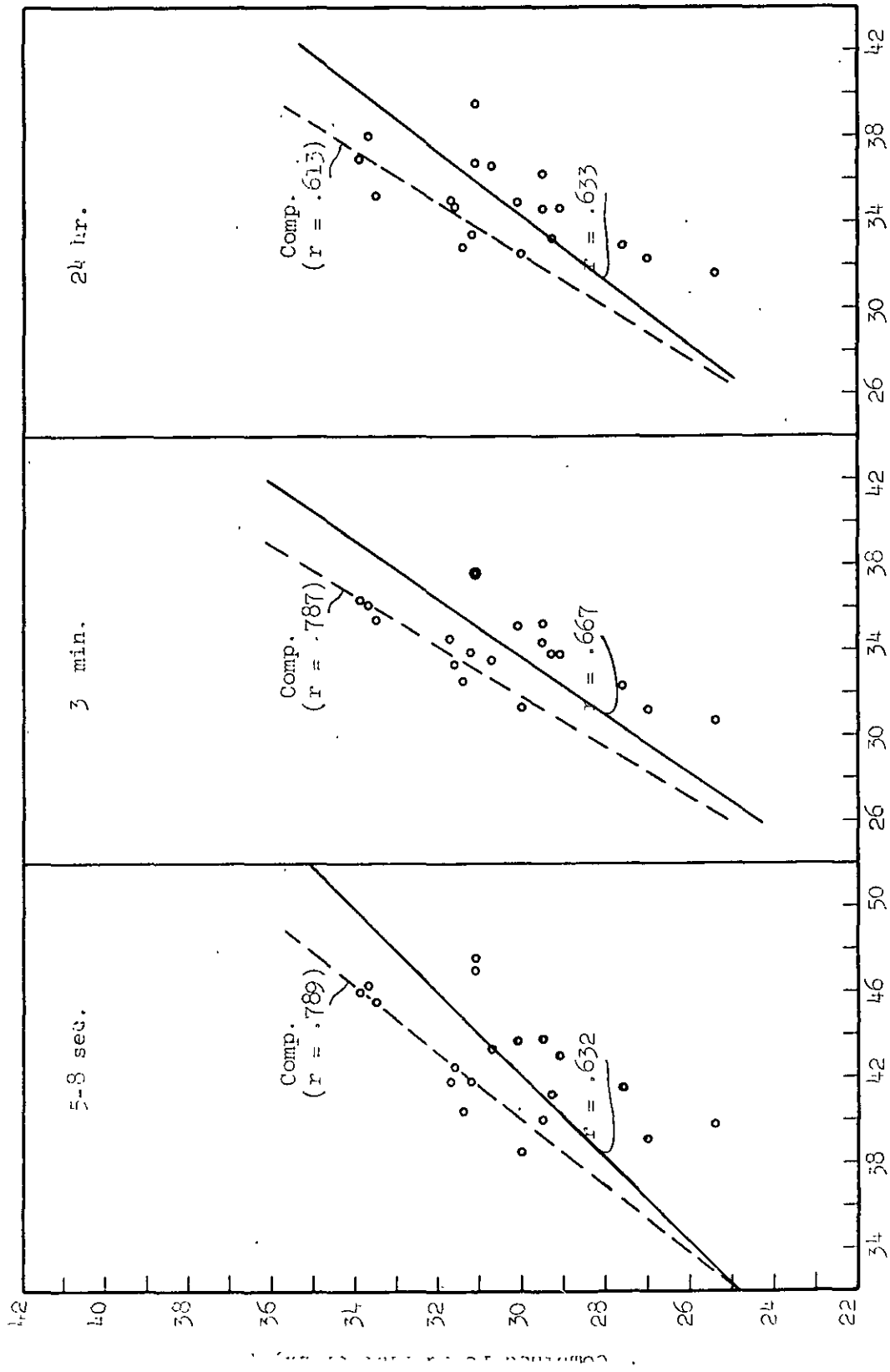


Figure 10. Relationship between Concora Medium Test and Combined Board Flat Crush for Mill E (I.P.C. Results)

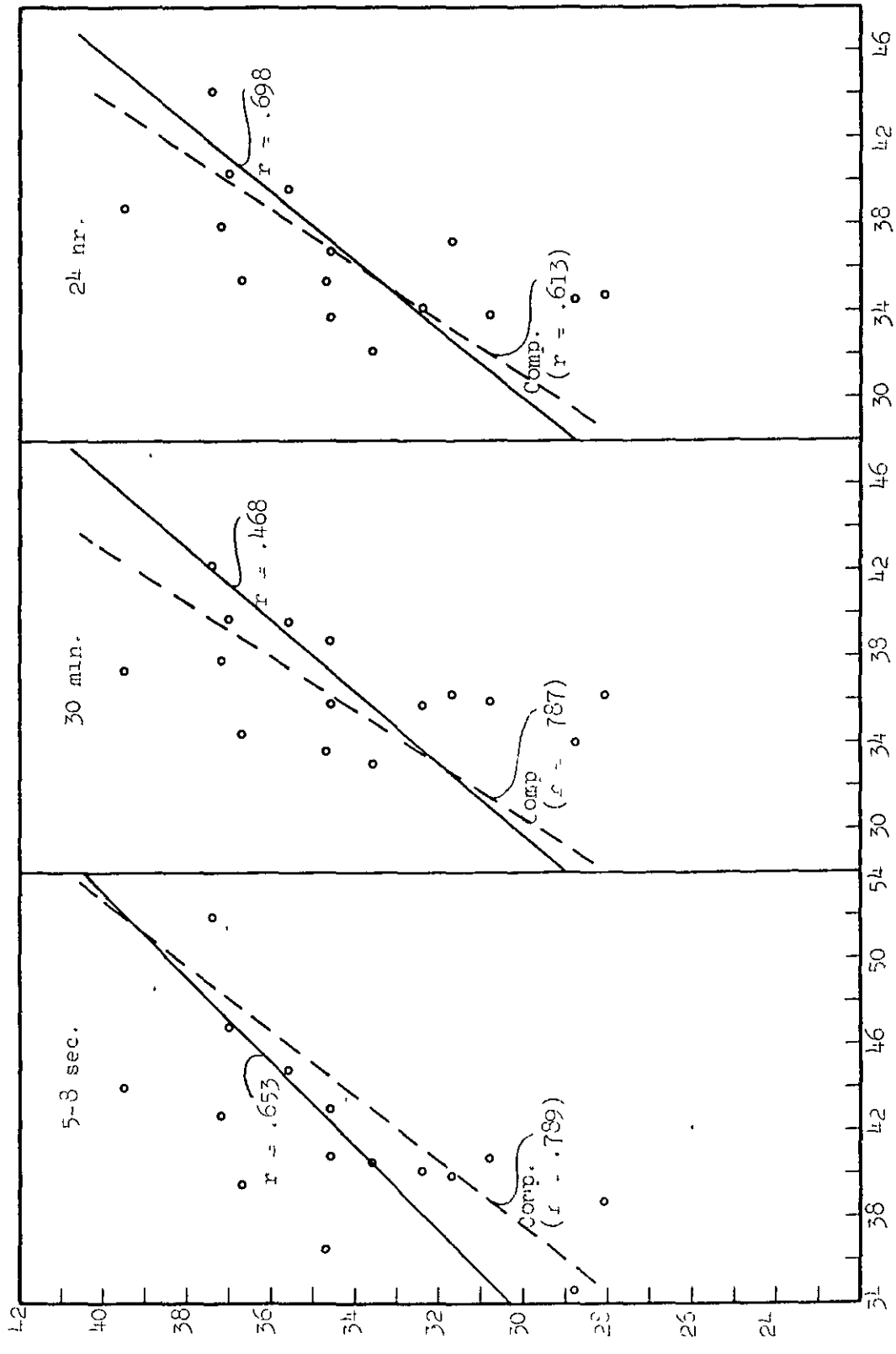


Figure 11. Relationship between Concora Medium Test and Combined Board Flat Crush for Mill F
(Mill Results)

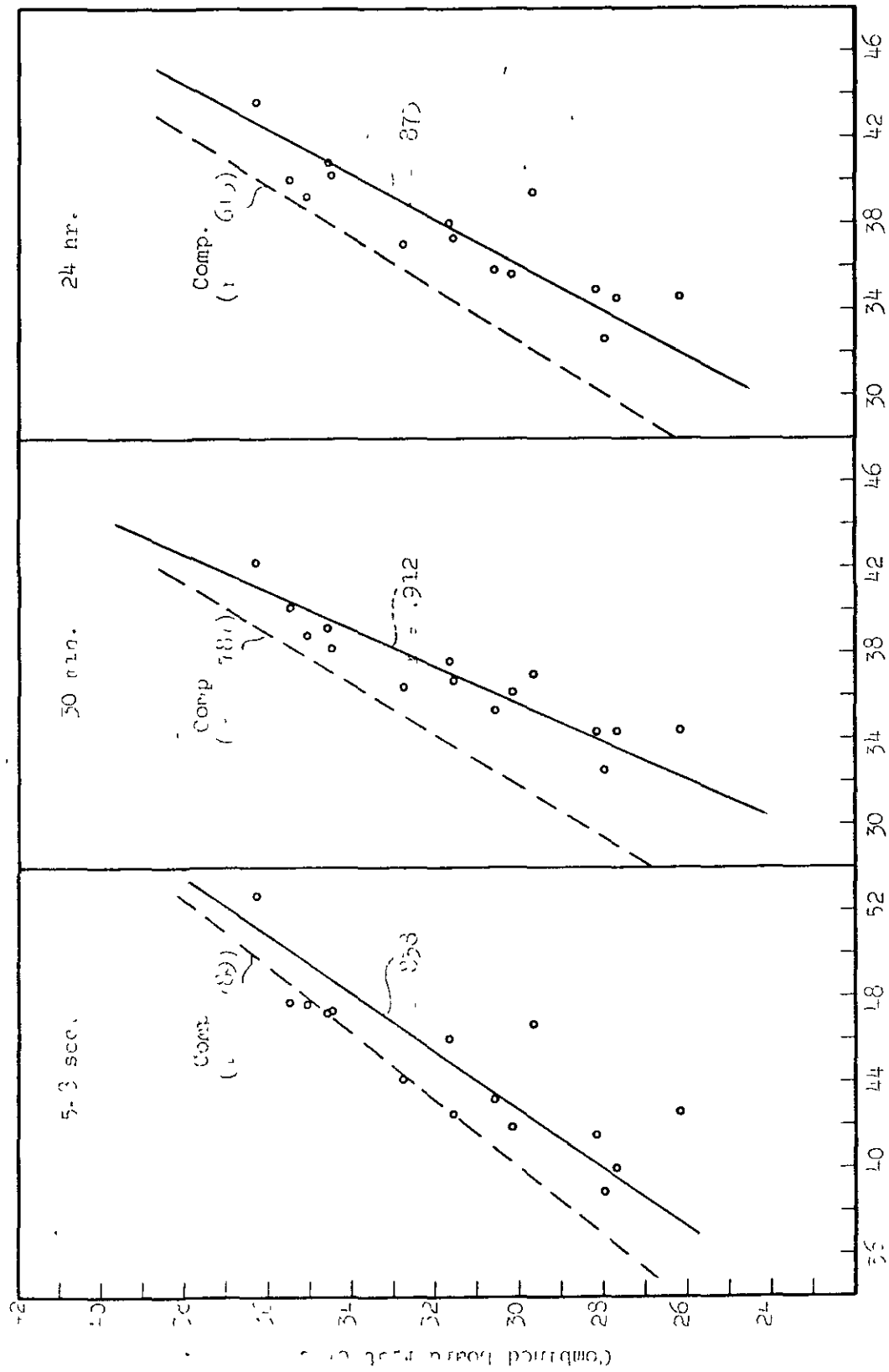
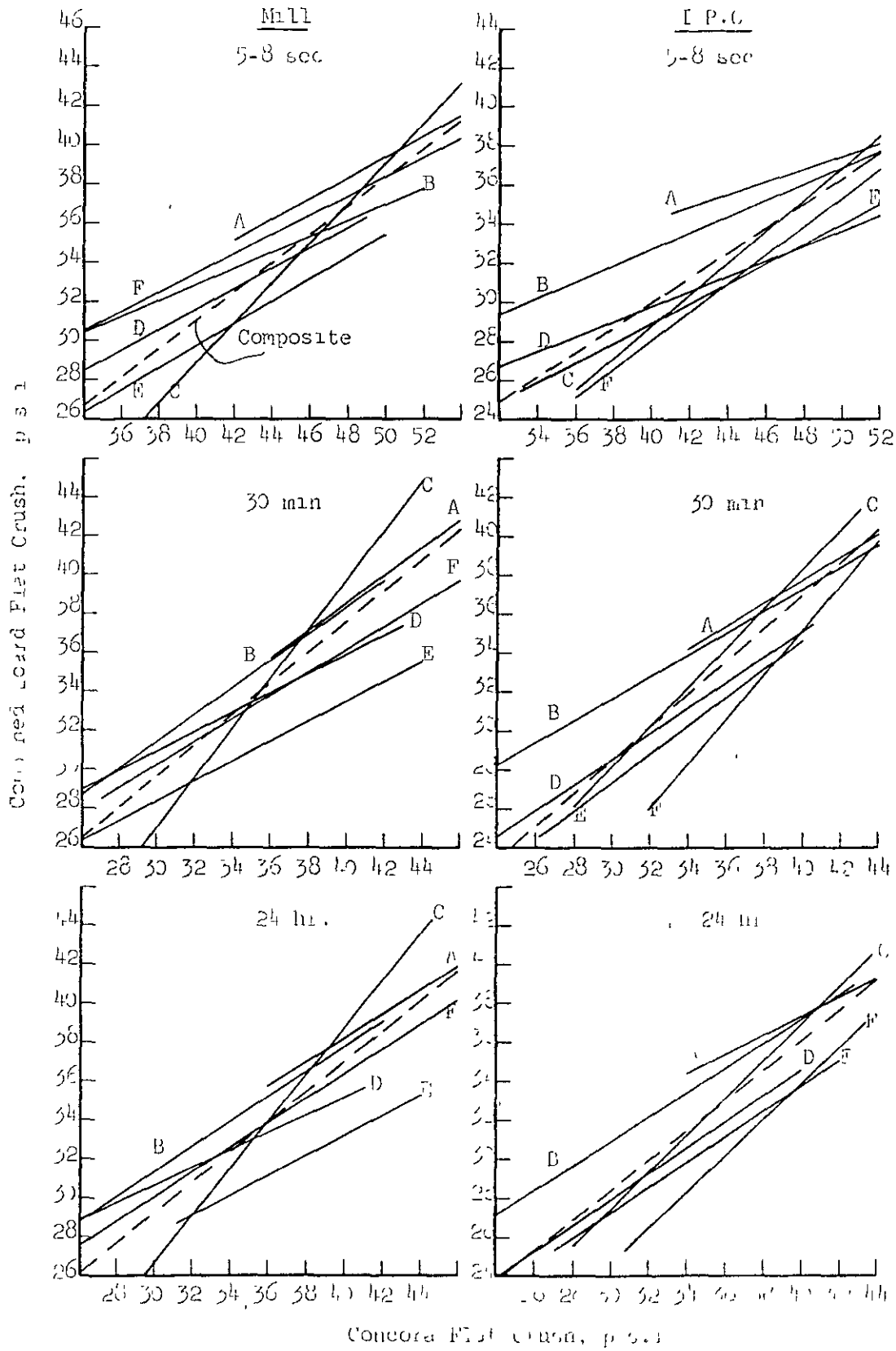


Figure 12 Relationship between Concora Medium Test and Combined Board Flat Crush for Mill P
(I.P.C. Results)


Mill
5-8 sec
I P.C.
5-8 sec
30 min
30 min
24 hr.
24 hr
Composite
A
B
C
D
E
F
Corrected Concora Flat Crush, psi
Concora Flat Crush, psi

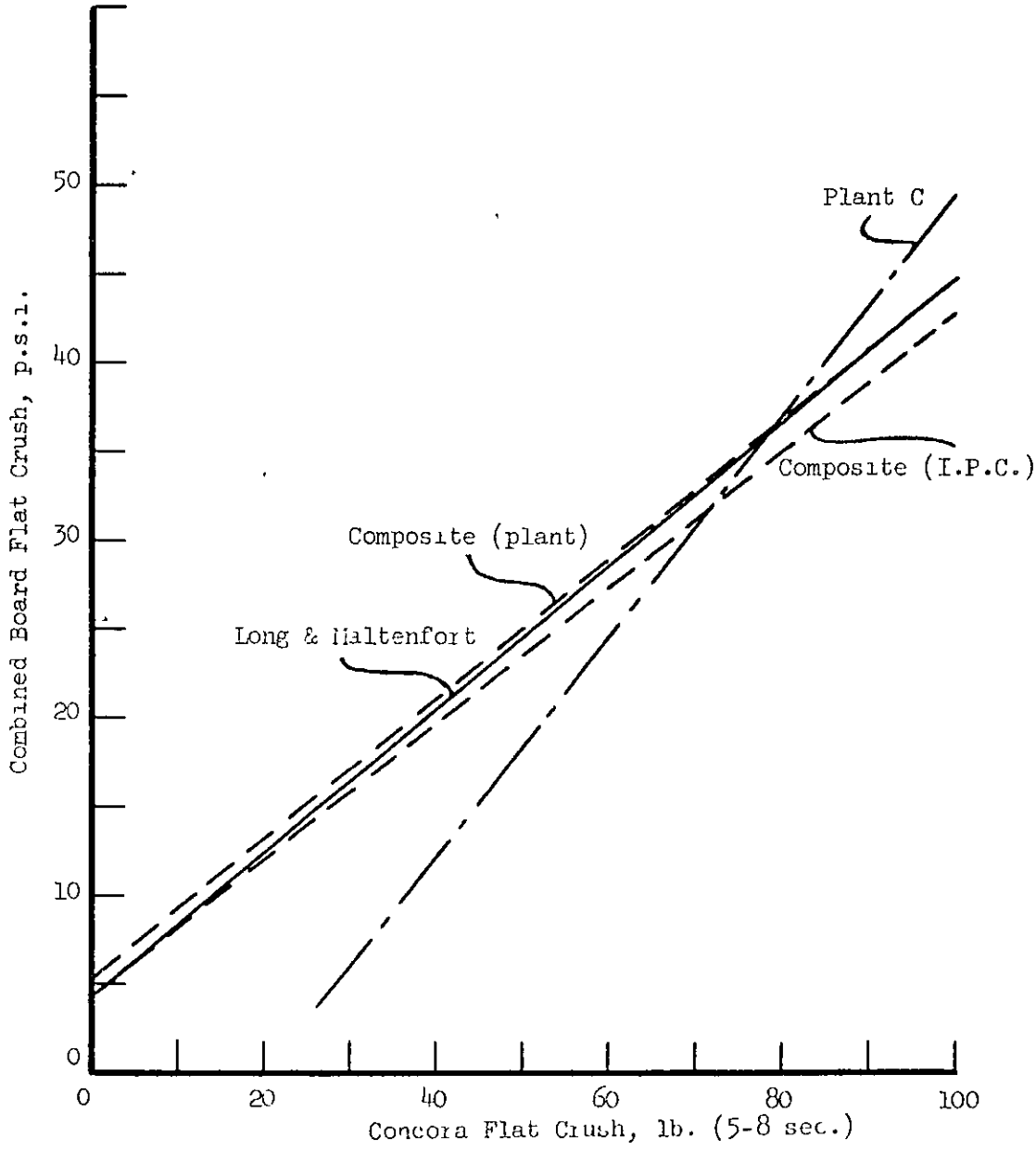


Figure 14 Comparison of A-Flute Regression Lines

CONCORA CONDITIONING TIME STUDY

RELATIONSHIP BETWEEN CONCORA AND COMBINED BOARD FLAT CRUSH

I. Purpose

To determine the relationship between combined board flat crush and Concora flat crush tested:

(a) immediately;

(b) after conditioning 30 minutes; and

(c) after conditioning 24 hours

It is proposed that this be done by sampling and evaluating corrugating medium and corresponding combined board manufactured during commercial runs on at least five different A-flute corrugators. The details of the experimental program are set forth below.

II. Sampling and Evaluation Program

A. Sampling

1. Selection of corrugators. It was agreed that at least five corrugators should be included in the study. The general consensus was that a greater number might be preferable and it was believed that a number of "extra" participants would be obtained from the parent committee membership.

2. Each participant will select two samples (175 or 200-lb. test A-flute board) per week per selected corrugator of 26-lb. "run of the mill"

corrugating medium and the corresponding combined board, for 15 weeks, all samples to be taken from same corrugator. The mediums sampled should be confined to those types customarily run by the selected corrugator. The corrugating medium is to consist of a strip at least 65 inches long taken from the front side of the roll as run and of such a width as to permit 13 by 13-inch sheets to be cut from the strip 4 inches away from the edge of the parent roll. The sheets are to be numbered and marked as shown in Fig. 1. After marking, the 13 by 13-inch sheets are to be cut in half as shown in Fig. 1. The "B" sheets are to be forwarded to The Institute of Paper Chemistry (see last paragraph for instructions), and the "A" sheets are to be retained by the converter for subsequent testing. Each corrugating medium sample shall be marked with the following information:

a. type and weight
b. manufacturer and machine number
c. roll number
d. trim width
e. date manufactured
f. sample number (a consecutive number from 1 to 30 assigned at the plant)

Record the information on duplicate data sheets (e.g., see Fig. 2). Retain one data sheet for the testing at the plant and forward the other data sheet with the corresponding medium and combined board samples to the Institute.

The combined board sample shall be taken just ahead of the location of the corrugating medium sample and shall consist of front side box blanks. The

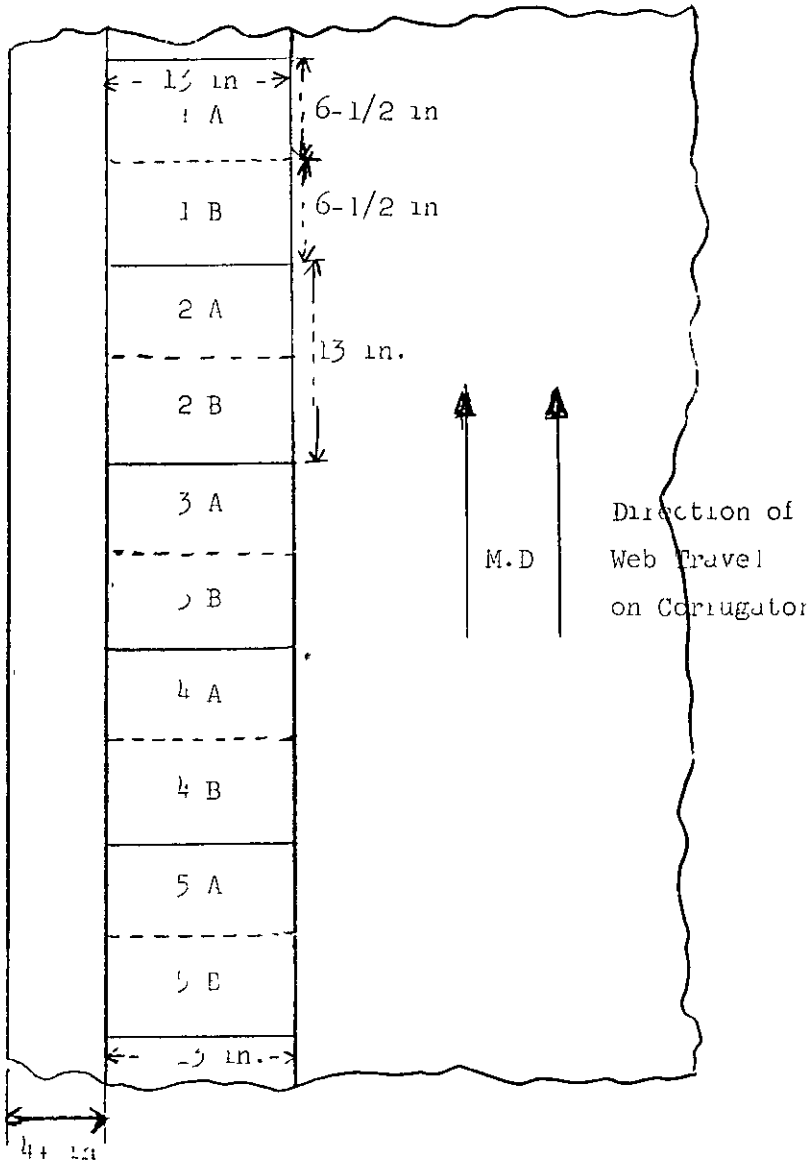


Figure 1 Medium Sampling Diagram

Converter _____ Sample No _____

Concora Conditioning Time Study

Sampling Information

CRFUGATING MEDIUM

Type _____ Weight _____

Manufacturer _____

Machine Number _____

Roll Number _____

Trim Width _____

Date Manufactured _____

MBLED BOARD

Series _____

Corrugating Speed _____

Adhesive S F _____

D F. _____

Date Corrugated _____

ampling and Special Cutting

As Specified. Yes _____ No _____

If no, please describe:

_____

* Multiply Concora total in pounds by 0 06 to convert to p s i

Concora Flat Crush, p s i.

Fluter No _____

Compression Machine: Type _____

Rate, lb./sec.

5-8 sec	30 ± 5 min.	24 ± 2 hours
1-1	1-2	1-3
1-4	1-5	1-6
2-2	2-3	2-1
2-5	2-6	2-4
3-3	3-1	3-2
3-6	3-4	3-5
4-1	4-2	4-3
4-4	4-5	4-6
5-2	5-3	5-1
5-5	5-6	5-4
Total		
Av , lb		
Av., p s i *		

Comb Board Flat Crush, p.s.i.

Spec. Size _____

Tester Type _____

Tester Rate, lb /sec. _____

1-1
1-2
2-1
2-2
3-1
3-2
4-1
4-2
5-1
5-2

Additional Information:

Figure 2. Data Sheet for Semiweekly Samples

blanks shall meet the normal manufacturing quality checks with respect to such factors as leaning flutes, fingerlines, adhesion, caliper, etc. The blanks shall be of sufficient width and accumulated length so as to permit cutting five 13 by 13-inch sheets 4 inches in from the front edge of the machine corresponding to the same sampling procedure as used on the medium except that the five sheets should not be cut in half. The combined board shall be as free of scorelines as possible. Each sheet is to be numbered and marked as to front edge and the sample is to be identified as follows:

a. series combined board
b. type of adhesive (Note: The same type of adhesive is to be used for all samples submitted from a given corrugator.)
c. date corrugated
d. type, manufacturer and roll number of medium
e. sample number (should correspond to medium sample number)

Record the sampling information on the same data sheet (see Fig. 2) used to record the sampling data for the medium. Cut flat crush specimens from each sheet of combined board as specified under "Evaluation".

Properly protect and package the medium with its corresponding combined board sample and forward with the sampling data to: R. C. McKee, The Institute of Paper Chemistry, Appleton, Wisconsin 54910.

B. Evaluation

1. Corrugating medium. To be evaluated for Concora flat crush by three different methods by each participant and by the Institute.

a. Tested "immediately" after fluting. "Immediately" is defined as 6-8 seconds from time the specimen emerges from the flutes

to the start of loading in the compression tester

b Tested after conditioning for 30 ± 5 minutes.

c. Tested after conditioning for 24 ± 2 hours.

[Note: When conditioning times do not fall within the limits noted above, the readings shall be so marked]

Each participant is to cut six specimens from each of the five "A" sheets (6-1/2 by 13 inches) as shown in Fig 3 Space the specimens across the sheet so as to leave at least an inch between specimens Number the specimens from 1 to 6 and test as follows:

	Specimen Number		
Sheet Number	5-8 sec. Conditioning	30 ± 5 min Conditioning	24 ± 2 hr. Conditioning
1A	1 and 4	2 and 5	3 and 6
2A	2 and 5	3 and 6	1 and 4
3A	3 and 6	1 and 4	2 and 5
4A	1 and 4	2 and 5	3 and 6
5A	2 and 5	3 and 6	1 and 4

Record the data on the data sheet containing the sampling information and forward the results to the Institute The Institute tests will be performed using the "B" sheets

The medium is to be preconditioned for at least 24 hours at less than 35% R H and conditioned at least 24 hours at 50 ± 2% R.H. and 73°F. prior to fluting in the 50% R H atmosphere.

3 Combined board To be evaluated for flat crush by each plant and the Institute. Each participant is to but two 5 square-inch circular specimens from each sheet from diagonal corners This will give a total of ten

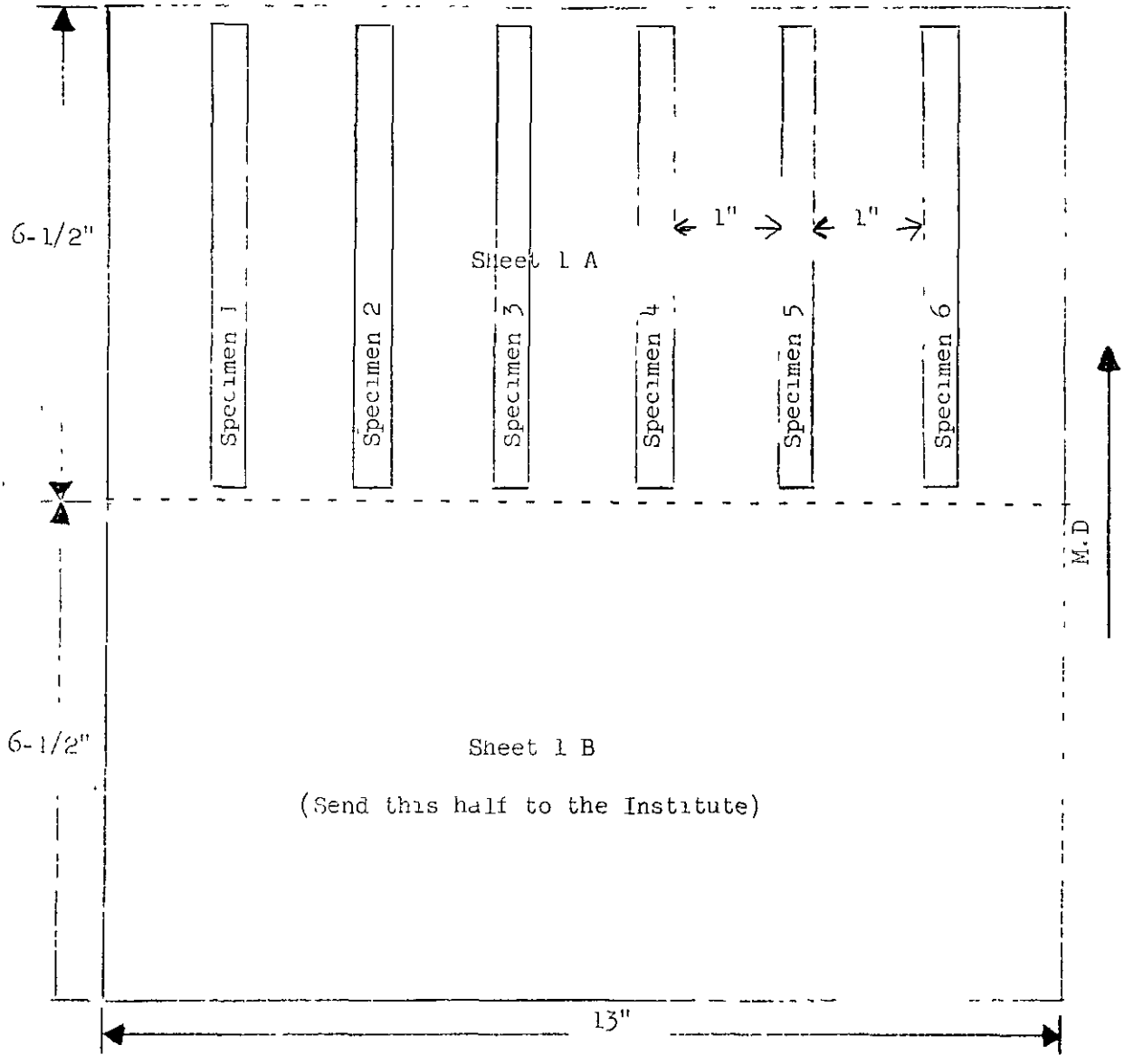


Figure 5 Concora Specimen Cutting Plan

specimens. The Institute tests are to be made on specimens cut from the other diagonal corners. If leaning flutes are encountered during the testing, the readings will be marked and averages will be computed with and without such readings.

The combined board is to be preconditioned for at least 24 hours at less than 35% R.H. and conditioned for 24 ± 2 hours at 50% R.H. and 73° F. prior to test

III Analysis of Results:

The results obtained above will be statistically analyzed to develop the relationship between combined board flat crush and the Concora flat crush determined by the three different degrees of conditioning. The correlation coefficient together with the degree to which flat crush can be predicted will indicate which method is most appropriate as a referee test

IV. Supplementary Program.

It is proposed that three commercial rolls of corrugating medium be selected for fabrication on each of the five corrugators used in II above. The International Paper Company will arrange to supply three rolls cut from the same position in consecutive reels. They will specify the shipping schedule and roll protection Each plant will reship (best way, prepaid) the rolls to the next plant Each corrugator will fabricate 2000 or less lineal feet of combined board using each of the three rolls. [Note It is planned to mark each traveling roll when rewound at intervals of approximately 5000 lineal feet Each corrugator shall confine his corrugating to within this length.] Samples of medium and the corresponding board are to be taken as in II above

To insure that each converter samples the roll and combined board on the same side, one end of each roll is to be marked "test side." Samples must be taken from the "test side." The same procedure is to be used in the sampling, testing, and reporting of the traveling rolls as described in II above. Record the sampling information and data on the special yellow forms provided for the "traveling roll phase" (see Fig 4) and forward to the Institute. The purpose of the "traveling rolls" is to determine the degree to which the five corrugators can achieve a common flat crush level per roll. This information will be most helpful in interpreting the results obtained in III above.

Converter _____ Sample No _____

Concora Conditioning Time Study

(Traveling Roll Phase)

Sampling Information

CORRUGATING MEDIUM

Roll Received from _____

Roll Forwarded to _____

Manufacturer _____

Machine Number _____

Roll Number _____

Trim Date _____

Date Manufactured _____

LINER BOARD

Series _____

Corrugating Speed _____

Flute S F _____

D F _____

Date Corrugated _____

Is plain or Special Cutting

As Specified Yes _____ No _____

If not please describe

_____

Multiply Concora total in pounds by 0.06 to convert to p s i

Concora Flat Crush, p s i

Fluter No _____

Compression Machine Type _____

Rate, lb /sec

5-8 sec	30 ± 5 min	24 ± 2 hours
1-1	1-2	1-3
1-4	1-5	1-6
2-2	2-3	2-1
2-5	2-6	2-4
3-3	3-1	3-2
3-6	3-4	3-5
4-1	4-2	4-3
4-4	4-5	4-6
5-2	5-3	5-1
5-5	5-6	5-4
Total		
Av, lb		
Av p s i		

Corr Board Flat Crush, p s i

Spec Size _____

Tester Type _____

Tester Rate, lb /sec _____

1-1
1-2
2-1
2-2
3-1
3-2
4-1
4-2
5-1
5-2

Figure 4.

TABLE I

TEST RESULTS FOR MILL A

No	Corr. Speed, f p m	Concora Flat Crush, p.s.i.[a] Mill 5-8 Sec, av	Mill 30±5 Min, av	Mill 24±2 Hr, av.	I P.C. 5-8 Sec, av	I P.C. 30±5 Min, av	I P.C. 24±2 Hr, av	Combined Board Flat Crush, p.s.i. Mill, av	Combined Board Flat Crush, p.s.i. I P C., av
1	180	56 0(93 3)	45 8(76 3)	48 2(80.3)	55.7(92.8)	43 3(72 2)	46 1(76 9)	45 2	40.5
2	250	50 2(83 6)	42 5(70 9)	44 1(73.5)	50.8(84.6)	40 3(67.1)	41.4(69 0)	40 7	36.8
3	250	-41 1(68 5)	-37 1(61.8)	37.7(62.8)	46 6(77.6)	37 7(62 8)	39.0(65 0)	38 3	38 9
4	250	49 6(82 7)	42.5(70 9)	43.7(72 9)	53 2(88.6)	41.9(69 9)	44.5(74 2)	39 4	37 3
5	190	50 3(83.8)	41.9(69 8)	40.4(67.3)	53.7(89.5)	39 7(66 2)	40 2(67 0)	36.9	-35.5
6	300	48 3(80 5)	40 1(66 9)	41 6(69 4)	50.2(83 6)	41 0(68.3)	42 6(71 0)	38.8	39.1
7	300	48 8(81 4)	39 9(66.5)	41 3(68 9)	49 8(83.0)	39 4(65 6)	41 2(68.7)	37.0	35.8
8	300	49 0(81 7)	40 8(68.0)	41.4(69 0)	50.7(84 5)	40.1(66.9)	40 1(66.9)	37.4	36.0
9	300	50 1(83.5)	41.4(69 0)	44.0(73 4)	52 9(88.2)	41.8(69 7)	42.1(70 2)	40 9	40.7
10	200	+56 6(94 4)	+48 1(80 1)	+49.0(81 7)	+59 8(99.7)	+45.7(76 2)	+48 4(80.7)	+45 6	+44.7
11	300	49 7(82 8)	39.5(65.8)	41.2(68 6)	51.9(86.5)	40.0(66 7)	39 5(65.8)	41.4	39.5
12	250	48 2(80 3)	40.4(67 4)	41.0(68.4)	51 3(85.5)	38.9(64.8)	39.7(66.1)	39.0	37.8
13	250	51.3(85.5)	42.5(70 8)	45 8(76 4)	55.3(88.9)	42.3(70 5)	42 7(71 2)	40 8	37 9
14	300	46.2(77 0)	38 9(64 8)	39 4(65.6)	49 0(81 7)	37 4(62 3)	39 0(65.0)	39.4	37 6
15	350	47 1(78 5)	41 6(69 3)	41 3(68.8)	50.6(84 4)	38 8(64.6)	40.4(67 3)	36.1	36.0
16	225	51 4(85 7)	42.9(71 5)	44.2(73 6)	52.3(87 2)	41.3(68.9)	43.1(71 8)	41.1	39 6
17	150	45 4(75 7)	38.6(64 3)	40.9(68.2)	48.7(81 1)	38.4(64.0)	39 7(66 2)	36.7	36.0
18	185	48.1(80 2)	40.8(68 0)	41.7(69 5)	49.6(82 6)	38 3(63 9)	40 0(66 7)	36 5	36.3
19	175	49 7(82 9)	39 9(66 5)	40.7(67.9)	51.2(85.4)	38.2(63 6)	40 1(66 9)	-36 0	37.0
20	200	51.9(86 5)	43 2(72 0)	41.9(69.8)	54.5(90.8)	41.8(69.7)	41.8(69 7)	41.1	37 7
21	150	49 5(82 5)	41.2(68 7)	41.8(69.7)	50 3(83 9)	40.6(67 6)	41.9(69 8)	41.6	38 3
22	125	45.4(75 7)	39 4(65.7)	39 6(66.0)	-44 9(74.9)	39.2(65 3)	39 0(65 0)	37 7	36 3
23	125	52 1(86.9)	40.2(67 0)	42.1(70 1)	52 7(87.8)	40.7(67.9)	41.2(68 6)	38.5	35.8
24	200	50.0(83 4)	39 7(66.2)	39.9(66.5)	51.2(85.3)	38 0(63 3)	39 5(65.9)	38 2	36.5
25	185	50 7(84 5)	41 7(69 5)	42.2(70 4)	53.3(88.8)	42 1(70.2)	41.9(69 8)	38.3	37.9
26	200	48 4(80 6)	39 8(66 4)	39.8(66 3)	50.9(84 8)	39.3(65.5)	39.2(65 4)	37.6	37 3
27	180	49.2(82.0)	40.6(67 6)	39.7(66.2)	49.7(82 8)	42.2(70.8)	40.9(68 2)	37.6	38.5
28	185	47 8(79.7)	37 7(62.9)	37 7(62.9)	48 8(81.3)	39.5(65.9)	40.3(67 2)	38.4	38 1
29	225	48 7(81 2)	38.2(63.7)	38.1(63.5)	47 0(78 4)	-36 2(60 3)	-36.7(61 2)	38.4	37 8
30	180	47 7(79.5)	37.6(62 6)	-36 5(60.9)	47 9(79.8)	38.7(64 5)	36.9(61 5)	38.4	37 9

[a] value in parentheses is the test result in pounds.

TABLE II

TEST RESULTS FOR MILL B

No	Corr Speed, f p m	Concora Flat Crush, p s i [a]						Combined Board Flat Crush, p s i	
		Mill			IPC				
		5-6 Sec, av	30±5 Min., av	24±2 hr, av.	5-6 Sec, av	30±5 Min., av	24±2 Hr., av	Mill, av.	IPC, av
1	250	43 7(72 8)	34 6(57 7)	35 5(59.1)	43 8(73.0)	34.3(57 1)	35 1(58 5)	36.0	35 2
2	250	41.8(69 6)	33 3(55 5)	34 6(57.7)	41.7(69 5)	32.1(53 5)	33 5(55 9)	34 2	33 5
3	250	44 5(74.1)	35 8(59 6)	35.9(59 9)	43.3(72 2)	35 2(58 7)	35 9(59.9)	36.1	35 7
4	260	46.3(77 2)	35.9(59 9)	36 5(60 9)	43 7(72 9)	34 9(58 2)	35.3(58 8)	37 8	+38 3
5	235	44 9(74.9)	35 2(58 7)	35.8(59.7)	45.1(75.1)	34.4(57 4)	35 8(59 7)	35 8	35 4
6	245	50.8(84 7)	38.4(64.0)	38 9(64.9)	46.2(77 0)	37.1(61.8)	38 3(63 9)	37 0	36 6
7	235	43.1(71.8)	33 5(55.8)	34.3(57.1)	42.3(70 5)	32.7(54.5)	34.8(58 0)	34 3	33.8
8	240	47.4(79 0)	36 2(60.3)	38.2(63.6)	42.7(71 1)	32.8(54.6)	35 2(58.6)	34 1	34.3
9	255	45.6(76 0)	36.5(60 8)	36 3(60.5)	45 3(75.5)	35.2(58.7)	36.5(60.9)	35.4	34 0
10	250	41 1(68.5)	33.4(55 6)	33.4(55.7)	41 6(69.3)	32.6(54.3)	33.3(55.5)	36.5	34.6
11	255	48 5(80.8)	38 0(63.3)	37.7(62.9)	47.5(79 2)	37.3(62.1)	37.0(61.6)	35.5	34.3
12	265	48.3(80 5)	37.0(61 6)	37 1(61 9)	44.0(73 3)	34.0(56.6)	35 5(59 2)	+38 3	36.0
13	255	43.9(73 1)	34 4(57.4)	34.0(56 6)	42.8(71 3)	33.9(56 5)	34 3(57 2)	36 3	35 8
14	265	42 8(71.3)	32.7(54.5)	33.9(56.5)	41.3(68.9)	33.7(56.1)	34.3(57.1)	32.9	31 6
15	215	45.5(75.9)	35.8(59.7)	36 8(61.4)	43.7(72.8)	35.6(59.4)	36.1(60.1)	37 2	35 4
16	225	43.1(71.8)	34 8(58.0)	34.8(58 0)	44.5(74 1)	36.2(60.4)	37.2(62.0)	37 2	35.6
17	225	45 4(75 6)	34.7(57 9)	33.7(56.1)	44 1(73.5)	35.5(59.2)	35 6(59.3)	34.6	33.1
18	235	49 1(81.8)	35 9(59.8)	36 3(60.5)	47.6(79.3)	37.6(62.6)	37.4(62 3)	34.2	32 1
19	250	48 2(80.4)	37 1(61 9)	37 7(62 9)	47.0(78 3)	35.8(59.7)	37 0(61.7)	33.1	32.8
20	245	+51 4(85 7)	39 0(65 0)	40 0(66 6)	+49 1(81 8)	+39 0(65.0)	+39 0(65 0)	32.8	32.8
22	250	-32 5(54 1)	-26.3(43.8)	-27.8(46.3)	-31 9(53.2)	-25.6(42.6)	-25.9(43.1)	-25 8	-26.2
23	260	45 1(75 1)	35 9(59 8)	35 5(59.1)	42.1(70 1)	34 0(56.7)	35.2(58 7)	37 6	36.2
24	255	42.6(71 0)	32 3(53 8)	34 4(57.4)	40 3(67 2)	33 3(55 5)	32.8(54.6)	32.4	33 7
25	250	51 0(85.0)	+39 3(65 5)	+40 4(67 3)	48 4(80 6)	37.6(62 6)	37 6(62 7)	36.0	36.3
26	245	42 9(71 5)	33.5(55 9)	33.9(56 5)	41.0(68 4)	33 1(55 1)	32.6(54 4)	32 0	31.8
27	255	37 3(62.2)	29.0(48 4)	30 1(50 2)	37 8(63 0)	31.4(52 3)	30 6(51 0)	29 3	28 5
28	250	43 7(72 9)	35 0(58 4)	35 3(58.8)	44.3(73 8)	36 4(60 7)	37 8(59 6)	36 1	34 9
29	265	47 5(79 2)	35 2(58.7)	38.0(63 3)	44.3(73 9)	35 2(58 7)	35 5(59 1)	38 3	37 3
30	265	42 8(71.4)	35 4(59 0)	35.3(58 8)	40.0(66.7)	32.5(54 1)	33.7(56.2)	34 9	34 2

[a] Value in parentheses is the test result in pounds

TABLE III

TEST RESULTS FOR MILL C

No	Corr Speed, f p m	Concora Flat Crush, p s i.[a] Mill 5-8 Sec , av	Mill 30±5 Min , av.	Mill 24±2 Hr., av.	I P.C. 5-8 Sec , av	I P.C. 30±5 Min , av.	I P.C. 24±2 Hr , av	Combined Board Flat Crush, p.s.i Mill, av.	Combined Board Flat Crush, p.s.i I.P C., av
1	--	40 3(67 1)	-30 9(51 5)	32 9(54 8)	40 1(67 3)	30 4(50 7)	-30.8(51.3)	28 4	27 8
2	--	46 6(77 7)	36 1(60 2)	38.7(64 5)	47 0(78 1)	34 4(57.4)	35 5(59.2)	34 9	35 1
3	--	44 0(73 4)	33.2(55 3)	34 1(56.9)	43 4(72 3)	33.4(55.6)	35 3(58 8)	30 0	30 7
4	--	-38.9(64 9)	31.1(51 9)	-31.4(52 4)	-38 3(63.9)	-29 2(48 7)	31 0(51 6)	-25 3	-26 3
5	--	42.2(70.3)	32.3(53.8)	32.9(54.8)	41.3(68 9)	31.0(51 7)	32.3(53.9)	29.0	29.8
6	--	46 0(76 6)	36.2(60.4)	36.9(61 5)	45 9(76.5)	34 7(57.8)	34 9(58.1)	34 7	36 5
7	100	44 1(73.5)	34 4(57.4)	35 1(58.5)	42 7(71 1)	31 8(53.0)	34 3(57 1)	34 4	33 4
8	140	48.7(81 1)	37 7(62.8)	37 9(63.1)	49.0(81 6)	35 8(59.7)	37 8(63.0)	35 2	33 6
9	200	43 5(72 5)	36 4(60 6)	36.5(60 8)	45 4(75 6)	35 6(59.3)	36 6(61.0)	33 7	33.2
10	300	47 3(78 9)	37 3(62 1)	38 0(63 4)	47 1(78 5)	35 5(59 2)	36 8(61.3)	35 0	33 3
11	180	45.1(75.2)	35.5(59 2)	36 1(60 2)	42 9(71 5)	33 9(56.5)	34 8(58 0)	32 5	33 0
12	300	42 7(71 1)	35.5(59 2)	35 6(59 3)	44 0(73 3)	34 4(57 3)	35 2(58 7)	30 3	30 5
13	250	44 9(74 9)	37 0(61 7)	35 9(59 8)	44 0(73 3)	33 8(56 3)	35 6(59 4)	34.2	33.5
14	100	39 2(65 4)	31 7(52.8)	33 1(55 2)	39 9(66 5)	30.4(50 6)	32 7(54.5)	31 1	29 9
15	250	43 0(71 6)	33 6(56 0)	35 0(58 4)	43 7(72 9)	34 7(57.9)	35 6(59 4)	33 0	34 0
16	340	43 2(72.0)	33.4(55.6)	35 3(58.9)	42.8(71 4)	33 4(55.7)	35 0(58 3)	29 6	29 7
17	520	43 9(73 2)	34 0(56 7)	34 7(57.9)	44 6(74 3)	34 4(57 3)	35 2(58 7)	36 7	34 1
18	300	41 1(68.5)	33.5(55 9)	34 8(58 0)	43.4(72.3)	33.4(55 7)	34 0(56 7)	29.8	29 4
19	300	43.7(72 8)	34.4(57.4)	34.6(57 7)	43.4(72 4)	33.3(55 5)	34.1(56 9)	35 2	35 0
20	275	42 2(70 4)	35 0(58 4)	34.0(56.7)	42.8(71 3)	34.0(56 7)	34 7(57.9)	35 4	31.7
21	250	44 0(73 4)	34 6(57 6)	34.9(58 2)	44 6(74 4)	33.6(56 0)	35 6(59 4)	36 3	34 4
22	300	+51 7(86 2)	+41.9(69 9)	+43 1(71.8)	+52.7(87.9)	+41 0(68.4)	+43 6(72 6)	+41 5	+40 4
23	450	43 3(72 1)	33.2(55 3)	33.5(55 9)	43.7(72 8)	33 3(55 5)	33.4(55.7)	33 8	32.0
24	200	40.9(68.2)	31 3(52.1)	33 4(55 7)	42 8(71 3)	33 4(55 6)	33 7(56 1)	28 6	27.9
25	275	40 7(67.8)	32.5(54.1)	32 8(54 7)	41 5(69.1)	31.7(52.8)	31.8(53 0)	29 9	28 4
26	200	44 7(74 5)	32 8(54 7)	34 4(57.4)	44.9(74 9)	34.5(57 5)	34 1(56 9)	29 0	28 1
27	250	44 3(73.9)	36 4(60 6)	36.5(60 9)	46 7(77 8)	35.3(58 8)	35.4(59 0)	33 1	31 7
28	200	43 7(72.9)	34 5(57 5)	34.9(58 1)	44 0(73 4)	34 9(58.2)	34 0(56 7)	34 7	33 2
29	300	44.5(74.2)	34 6(57.6)	35 9(59.8)	46 3(77 1)	35.8(59 7)	38.0(63.3)	31 6	33.6
30	330	44.4(74 0)	32.3(53 8)	32 8(54.6)	44.6(74.3)	34.9(58.2)	33.7(56.1)	30 4	32 6

[a] Value in parentheses is the test result in pounds.

TABLE IV

TEST RESULTS FOR MILL D

No	Corr Speed, f p m	Concora Flat Crush, p s i [a] — Mill — 5-8 Sec, av	Mill — 30±5 Min, av	Mill — 24±2 Hr, av	— I P C. — 5-8 Sec, av	I P C. — 30±5 Min, av	I P C. — 24±2 Hr, av	Combined Board Flat Crush, p s i — Mill, av	Combined Board Flat Crush, p s i — I P C., av
1[b]	--	41 2(68 6)	33 5(55 3)	36 3(60 5)	41 7(69 5)	32 7(54 5)	36 4(60 6)	34 2	30 8
2	--	40 0(66 6)	33 3(55 5)	34.3(57 1)	41 5(69 1)	32.2(53 6)	32.3(53.9)	31 8	30 2
3	--	42 5(70 8)	33 7(56 1)	34 9(58 2)	40.6(67.6)	33 1(55 1)	34 3(57 1)	33 9	32 3
4	--	43 4(72 2)	37 0(61 8)	36 1(60 1)	41.9(70 0)	35 2(59.0)	34 3(57 0)	34 6	33 2
5	--	+45 4(75 6)	+38 1(63 5)	+40 3(67 1)	+46 2(77 0)	+36 6(61.0)	+37.1(62 0)	33 7	32.0
6	--	43 6(72 6)	35 8(59 7)	36 6(61 0)	42.6(71 0)	34 4(57.3)	35 5(59 2)	32.9	30.8
7	--	44 7(74 5)	35 9(59 8)	36.8(61 4)	42.2(70 3)	33 0(55 0)	34 9(58 1)	32 3	30 4
8[b]	210	41 9(69 9)	32 9(54 9)	35 5(59 2)	45.1(75 1)	34 7(57.8)	37 1(61 8)	35 5	33 9
9[b]	225	35 9(59.8)	31 7(52 8)	32 3(53.9)	39.4(65.6)	30 4(50 7)	30 9(51 5)	29 0	27.1
10[b]	280	36 8(61.4)	30 0(50.0)	32.5(54.1)	38.3(63 8)	29 8(49.6)	31 1(51 8)	29 8	27.6
11	260	-32 6(54.4)	-28 3(47 2)	29 8(49.6)	-36 1(60 1)	-29 2(48.7)	-29 2(48 7)	-25 2	-24 4
12	275	40 6(67.6)	31 1(51 8)	31 2(52 0)	39 0(65 0)	32 1(53 5)	32 8(54 7)	32 5	31.7
13	275	37 6(62.7)	31 0(51 7)	29 9(49.8)	38 2(63.6)	30 4(50 6)	32 2(53 7)	30 7	29.2
14	260	38 2(63 7)	32 3(53 8)	31 6(52.7)	39 5(65.9)	32 5(54 1)	32 6(54 3)	33 1	31.3
15	280	40 3(67 2)	31.6(52 6)	32.7(54 5)	41.2(68 6)	33 5(55.9)	32 9(54 9)	30 6	29 2
16	270	42 7(71 2)	35.2(58 6)	35.3(58.8)	44.6(74 3)	34 9(58 2)	35.6(59 4)	31 1	30.4
17	275	40 4(67 3)	31 8(53 0)	32 0(53 4)	41 2(68 6)	33 5(55 8)	32 8(54 6)	30 7	29 2
18	210	43 3(72 1)	33.4(55 6)	34 7(57 9)	40 6(67.7)	33 2(55 3)	33.5(55 8)	+36 7	+34 1
19	210	41.6(69 4)	34 7(57 8)	34.8(58 0)	41 4(69 0)	33 2(55.4)	33.8(56.3)	33.9	30 9
20	220	38 2(63 7)	31.0(51 6)	32 5(54 1)	38 6(64.4)	31.4(52 3)	32.0(53 3)	35.2	32 7
21	210	39 1(65 1)	32 4(54.0)	32.3(53 8)	39.5(65 9)	32 9(54 9)	33.5(55 9)	34.5	32 2
22	275	40 0(66 6)	31 2(52.0)	32.9(54 9)	40 6(67 6)	32 6(54.4)	33.2(55.3)	31.2	29 7
23	255	43 6(72.6)	34.1(56 9)	36 0(60.0)	44 0(73.4)	36 0(60.0)	36.0(60 0)	31.6	31 0
24	275	39 4(65 6)	30 3(50 5)	32.3(53 8)	39 5(65.8)	32 0(53 3)	32.8(54 7)	31 1	29.2
25	275	39 3(65 5)	31 7(52 9)	31 7(52.8)	40 0(66 7)	33.0(55 0)	33 5(55 9)	31 6	29 2
26[c]	260	40 6(67 6)	31 8(53 0)	33 4[c](55 7)	45 4(75.7)	33 8(56 4)	36 1(60 1)	31 4	29 3
27[c]	260	40 6(67 7)	32 1(53 5)	32 7[c](54 5)	43 3(72 1)	32.3(53 8)	32.6(54 4)	31.7	28 5
28[c]	275	35 8(59 7)	29 0(48 3)	-29 6[c](49 4)	38 8(64 7)	-28 7(47 9)	30 5(50 9)	31 5	28 5
29[c]	260	34 3(57 1)	29 0(48 3)	30 4[c](50 7)	38 0(63 3)	29 2(48 7)	31 4(52 4)	30.8	28.7
30[c]	260	36.1(60 1)	30.1(50 1)	30 5[c](50.9)	38 2(63 6)	29.6(49 3)	31.5(52.5)	31.5	28 4

[a] Value in parentheses is the test result in pounds
[b] Bogus results
[c] Samples on which several flutes failed from tape before the end of conditioning period
Loose flutes were tied down to tape prior to testing

TABLE V

TEST RESULTS FOR MILL E

No.	Corr. Speed, f.p.m.	Concora Flat Crush, p.s.i.[a] Mill 5-8 Sec., av.	Mill 30±5 Min., av.	Mill 24±2 Hr., av.	I.P.C. 5-8 Sec., av.	I.P.C. 30±5 Min., av.	I.P.C. 24±2 Hr., av.	Combined Board Flat Crush, p.s.i. Mill, av.	Combined Board Flat Crush, p.s.i. I.P.C., av.
1	400	40 3(67.2)	36.2(60.4)	36.9(61 5)	40 0(66.6)	34.3(57.2)	34.6(57.6)	30.4	29.5
2	390	42 4(70 6)	36 1(60.2)	37 6(62.7)	43.8(73.0)	35.2(58.6)	36.2(60.4)	31.7	29.5
3	370	45 7(76.1)	38.3(63.9)	38.5(64.2)	46.3(77.2)	36.1(60.2)	38.0(63.4)	33.1	33.7
4	410	45.6(76.0)	37.1(61.9)	37.9(63.1)	46.0(76.7)	36 3(60.5)	36.9(61.5)	33.6	+33.9
5	400	42 5(70.9)	34.3(57 2)	34 7(57.8)	41.8(69 7)	34.5(57.5)	35.0(58.4)	31.5	31.7
6	370	38.8(64.7)	32.5(54.2)	32.9(54.8)	-38.5(64.1)	31.3(52.2)	32.5(54.1)	30.0	30 0
7	400	39 8(66.3)	-31.1(51.8)	-32.4(54.0)	40.4(67.4)	32.5(54.2)	32.8(54.6)	31.1	31.4
8	400	42.4(70.6)	33.5(55.8)	34.0(56.6)	41.8(69.7)	33.9(56.5)	33.4(55 7)	31 0	31.2
9	380	41.5(69.1)	35 6(59.3)	37 7(62 8)	41.2(68.7)	33.8(56.3)	33.2(55.3)	29.9	29.3
10	400	39 8(66 3)	32 2(53.7)	33.2(55.3)	39.8(66.4)	-30 7(51.2)	-31.6(52.7)	-26.3	-25.4
11	380	46 0(76.6)	37.6(62.6)	37 8(63.0)	45 5(75.8)	35.4(59.0)	35.2(58 7)	+35.0	33.5
12	380	+47.5(79.1)	39 9(66.5)	+41 0(68.4)	+47.6(79.4)	+37 6(62.6)	+39.5(65.8)	31.7	31.1
13	340	46 6(77.7)	+40 2(67.0)	40.0(66 7)	47.0(78.4)	37.6(62.6)	36.7(61.2)	32.1	31.1
14	405	43 5(72.5)	36.3(60.5)	37.2(62.0)	42 5(70.8)	33 3(55.5)	34.7(57.8)	33.0	31.6
15	400	42 6(71.0)	36.2(60.3)	36 3(60 5)	43.3(72.2)	33.5(55.8)	36.6(54.4)	32.7	30.7
16	395	44 4(74 0)	37.2(62.0)	37.3(62.2)	43.7(72.8)	35.1(58.5)	34.9(58 1)	32.7	30.1
17	380	41.6(69.3)	35.7(59 5)	35.8(59.6)	43 0(71.6)	33.8(56 3)	34.6(57.6)	31.1	29.1
18	380	39.1(65.1)	35.0(58.4)	34.1(56.8)	41.5(69.1)	32.3(53.9)	32.9(54.8)	28 5	27.6
19	385	-37.5(62.5)	33.7(56.1)	33.7(56.2)	39.1(65.1)	31.2(52.0)	32.3(53.8)	27.7	27:0

[a] Values in parentheses is the test result in pounds.

TABLE VI

TEST RESULTS FOR MILL F

No	Corr. Speed, f p m	Concora Flat Crush, p.s.i [a] Mill 5-8 Sec., av	Mill 30±5 Min., av	Mill 24±2 Hr., av.	I P C 5-8 Sec., av.	I P C 30±5 Min., av.	I P C 24±2 Hr., av	Combined Board Flat Crush, p s i Mill, av.	Combined Board Flat Crush, p s i I P.C., av
1	380	44 8(74 7)	39 6(65 9)	39 6(66.1)	47.2(78 6)	39 1(65.2)	40 8(68 0)	35.6	34 6
2	330	46.8(78 0)	39.7(66 2)	40 3(67.2)	47.7(79 5)	40.1(66 8)	40.0(66.6)	37 0	35.5
3	310	39.9(66 5)	36.2(60.3)	37 2(62.0)	42 5(70.8)	36.7(61.2)	37 3(62.2)	31 7	31.6
4	370	+51.9(86.5)	+42 2(70 2)	+44.1(73 6)	+52.7(87.9)	+42.2(70.4)	+43.6(72.6)	37 4	+36 3
5	380	42 7(71 2)	37 8(63 0)	37 9(63.2)	47.3(78 9)	38.2(63.7)	40.2(67.0)	37 2	34.5
6	200	40 7(67.9)	35 9(59 9)	33.8(56 4)	-38.9(64 8)	-32.5(54.1)	-32.6(54.3)	30 8	28.0
7	250	40 5(67.5)	-33.0(55.0)	-32.1(53.5)	41 9(69.8)	36 1(60.1)	35 6(59 4)	33.6	30.2
8	300	40 1(66.9)	35 7(59 4)	34.1(56.8)	41 5(69 2)	34.3(57.1)	34.9(58.1)	32 4	28.2
9	400	43.0(71.7)	38 7(64.4)	33.7(56.2)	46.0(76.6)	37.6(62.7)	38.0(63.4)	34.6	31.7
10	200	-34 6(57 7)	34.0(56 6)	34 5(57.5)	40 0(66.6)	34.3(57.1)	34.5(57 5)	28.8	27.7
11	250	38 7(64 4)	36.2(60 3)	34.7(57.8)	42.6(71.0)	34 4(57.4)	34.6(57 7)	-28.1	-26 2
12	450	44.0(73.4)	37 3(62.2)	38 7(64 4)	47.6(79.3)	38.8(64.6)	39.2(65.3)	+39.5	35 1
13	350	40 8(68.0)	35.8(59.7)	36.7(61.2)	46.7(77 9)	37.0(61.7)	39 4(65.7)	34.6	29.7
14	300	39 5(65.8)	34.4(57.3)	35.4(59.0)	44 1(73.5)	36.4(60.7)	37.0(61.7)	36.7	32.8
15	400	36.5(60.8)	33.6(56.0)	35.3(58.8)	43.2(72.0)	35.3(58.8)	35 8(59.7)	34.7	30.6

[a] Value in parentheses is the test result in pounds

TABLE VII

CORRELATION RESULTS

Mill	Conditioning Time	N	Intercept	Slope	r	Av Diff, %	Percentage of Predictions within Indicated Limit ± 5%	± 10%	± 15%	Intercept	Slope	r	Av Diff, %	Percentage of Predictions within Indicated Limit ± 5%	± 10%	± 15%
			Mill Results							IPC Results						
A	5-8 sec.	30	12 37	0.542	0 673	3.65	63 3	100.0	100 0	21.37	0 322	0.507	3.62	83.3	100.0	100.0
	30 ± 5 min	30	10 46	0.702	0 693	3 55	76.7	100.0	100.0	14.12	0.591	0.625	3.22	80.0	100 0	100.0
	24 ± 2 hr.	30	14.06	0.602	0.720	3.51	73.3	100.0	100 0	18.09	0.482	0.613	3.22	66.7	100.0	100 0
B	5-8 sec	29	16 56	0.408	0 600	5.39	51.7	93.1	96 6	15.84	0.422	0.579	4.91	65.5	82.8	100.0
	30 ± 5 min.	29	10.69	0.692	0.689	4.64	62.1	93.1	100.0	14.89	0.559	0.566	5.04	62.1	82.8	100.0
	24 ± 2 hr.	29	12.00	0 643	0.620	5.07	51.7	93.1	93.1	11.84	0.635	0.656	4.48	65 5	89.7	100 0
C	5-8 sec.	30	-12.39	1.030	0.760	5 94	50.0	86.7	96.7	- 4 08	0.820	0.761	4.98	60 0	90.0	96.7
	30 ± 5 min.	30	-11 10	1.271	0.825	5.17	46 7	90.0	100 0	- 2 57	1.024	0.740	5.03	60 0	90.0	96.7
	24 ± 2 hr.	30	-10.72	1.233	0 774	5.85	46.7	83.3	100.0	- 1 61	0.967	0.770	4.88	60.0	86.7	100.0
D	5-8 sec.	30	14 52	0.441	0 616	4.51	63.3	93.3	100 0	14.72	0 378	0 445	4.77	56 6	90.0	96 7
	30 ± 5 min	30	15 82	0.503	0 534	4 41	76.6	90.0	96.7	8.64	0.663	0.637	4 35	60 0	93.3	100 0
	24 ± 2 hr	30	17.05	0 452	0.508	4.64	66.7	93 3	96.7	7.87	0 669	0 636	4.24	70 0	90.0	100.0
E	5-8 sec	19	6.98	0.570	0.779	3.28	84.2	94.7	100.0	8 47	0.512	0.632	4.98	52.6	94.7	100.0
	30 ± 5 min	19	12 76	0.517	0 600	4 62	68.4	94 7	100.0	5 30	0 735	0.667	5.02	42.1	100 0	100.0
	24 ± 2 hr.	19	12.42	0.518	0.600	4.65	63.2	94.7	100.0	7.26	0.664	0.633	4.86	52.6	94.7	100.0
F	5-8 sec.	15	12.91	0 511	0.653	5 71	40.0	86.7	93.3	- 1.40	0.737	0.838	4 51	73 3	86 7	100.0
	30 ± 5 min	15	12.15	0.601	0.468	6 92	46.7	73 3	93 3	-10.63	1.143	0.912	3 52	73.3	100 0	100 0
	24 ± 2 hr	15	11 36	0 624	0 598	6 40	40 0	80 0	93 3	- 3.90	0 943	0 873	3 87	73 3	93 3	100.0
Composite	5-8 sec	153	5 35	0 657	0.769	5 81	51 6	85.0	95.4	4.37	0.641	0 789	5.61	49.7	85 6	96 7
	30 ± 5 min	153	5 72	0 796	0 767	6 00	47.1	84.3	95 4	3.11	0 847	0.767	6 58	51 6	83 0	97 4
	24 ± 2 hr	153	5.85	0 779	0 763	6 06	49 0	80.4	94 8	3 21	0 825	0 793	5 59	49 6	85 6	96 7